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THE UNIVERSITY OF ALBERTA

Cognitive Strategies, Metacognition, and Knowledge Base of Gifted, Average, and Learning Disabled Children

by

© Seokee Cho

A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF Doctor of Philisophy
IN
Special Education

Department of Educational Psychology

EDMONTON, ALBERTA
Spring, 1986

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled Cognitive Strategies, Metacognition, and Knowledge Base of Gifted, Average, and Learning Disabled Children submitted by Seokee Cho in partial fulfilment of the requirements for the degree of Doctor of Philisophy in Educational Psychology.

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Date November 18th, 1985

ABSTRACT

This study investigated:

1. group differences among the gifted, the average, and the learning disabled in mathematics in learning spatial and verbal information from maps;
2. group differences in the kinds and the frequency of strategies used during three study-recall trials for each of two maps in information processes such as sampling, encoding, retrieval, and monitroing.
3. the relationship among learning performance, specific cognitive strategies, metacognitive strategies and knowledge base.

The participants in the study included 21 gifted, 17 average, and 14 learning disabled students from 14 grade four classes in the Edmonton Public School District. Tasks used in the study included reproduction of two different maps, navigation problem solving, and tests of map reading skills. Strategies were examined through the analysis of verbal and behavioral protocols collected during the study-recall trials

The data revealed that gifted subjects were superior to average and learning disabled subjects in learning both verbal and spatial information from maps. The group differences in verbal recall became greater over trials as the subjects repeated study-recalls of a map. The group differences were also significant in knowledge base in map reading skills and navigation problem solving.

Group differences were shown in the kinds of strategies and the frequency of each strategy use. Specifically, a larger proportion of gifted subjects used systematic or regionally focused sampling strategy than average and learning disabled subjects The number of subjects in each group using of spatial encoding strategies and retrieval strategieswas significantly different. Gifted subjects also used spatial encoding strategies and general relational encoding strategies more frequently than the average and the learning disabled. The gifted subjects were also more accurate in evaluating their learning progress, more frequently evaluated the difficulty level of a given task, and utilized given cues more often to check their recall.

Intercorrelations, partial correlations, and stepwise multiple regression analysis revealed that, among specific cognitive strategies, metacognitive strategies and knowledge base, a set of specific cognitive strategies accounted for the most variance of total recall. The second best predictor was knowledge base in map reading. The educational implication of the study and suggestions for further studies were discussed.

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1. INTRODUCTION

The current trend of attempting to isolate basic processes in perception, learning, memory search, problem solving and other cognitive activities through the study of variation in task performance began at least as early as the turn of this century. In the past 20 years, knowledge about basic processes of human cognition has increased markedly. Advancements have also been made in the study of complex human knowledge and in the study of such skills as language acquisition, reading and mathematical problem solving.

However, much less has been reported about our understanding of human differences in terms of information processing. The most common cognitive analyses of intellectual ability or achievement have been done by psychometric studies (Carroll, 1983). For example, to study mathematical ability, a battery of tests designed to measure the hypothetical components of mathematical ability is administered. The results are factor-analyzed to identify the cognitive elements of underlying the test battery. Factor analysis produces a characterization of mathematical ability in terms of various components. The components usually include a numerical factor, a spatial factor, a verbal factor, and a reasoning factor.

It is useful to know what kind of factors usually contribute to general cognitive ability. However, the factors are categorized according to the context of the learning materials, rather than the processes involved in problem solving. Consequently, factor analyses studies by themselves do not provide enough information about how individuals are different in terms of information processing.

The present study attempts to investigate individual differences in high level information processing which involves knowledge and control processes responsible for the acquisition of new information with variation in learning performance. This analysis based on an information processing approach should provide a better understanding of cognition.

The individual is viewed as a processor of information. It is assumed that the construction of a memory representation depends on an existing body of semantic knowledge and a collection of processes. The processes include those that control attentional focus, encode new knowledge, transform knolwedge into new internal units and integrate them with previously acquired knowledge. This approach suggests that individual differences in cognitive ability may be traced to the differences in basic information processes, specific cognitive strategies, metacognitive strategies, and knowledge in a content area.

Basic information processes involve cognitive processes that are independent of specific content knowledge and processes that operate on representations of symbols independent of their referent (Hunt, 1978, 1980). Cognitive strategies refer to the learner's active search for relationships between the input and information stored in long-term memory. Metacognitive strategies refer to the superordinate functions by which basic information processing mechanisms are organized to solve problems. Content knowledge refers to the amount and organization of domain-specific knowledge.

While there are relatively more studies in individual differences in basic information processes, particularly linguistic processes, fewer studies of immediate recall have considered the relationship between memory and high level information processing. High level information processing involves knowledge in long-term memory and cognitive and metacognitive strategies. Taking account of these factors, it can be hypothesized that if certain strategies facilitate learning, then the subjects who use these strategies should perform better than those who do not. Superior performance may arise in two ways. Good learners might use more strategies and more advantageous strategies for learning than poor learners. Alternatively, poor learners might use as many as, but less effective strategies than good learners. In addition, for learning of different types of information (e.g., spatial vs verbal information), the subjects should switch among a variety of strategies to enhance their learning depending on the type of information they are focusing on.

There have been a considerable number of studies which attempt to determine the relationships between the information processing strategies and learning performance (Borkowski & Varnhagen, 1984; Berry & Broadbent, 1984; Belmont & Butterfield, 1971; Dansereau, 1985; Flavell, 1970; Hagen, 1971; Hallahan & Kneedler, 1979; Pressley, Heisel, McCormick & Nakamura, 1982; Rohwer, 1978; Weinstein, 1985). The results of the studies in the area of information processing strategy training are of practical value to those who are concerned with improving learning performance of children. Also, they can give ideas as to what basic knowledge and strategies are required for successful learning performance of different group of children. The typical findings are that children who do not spontaneously use cognitive strategies can be trained to use them. In addition, performance level increases with the use of cognitive strategies (e.g., Naus, Ornstein, & Kreshtool, 1977; Ornstein, Naus, & Liberty, 1975; Pressley & Levin, 1977; Pressley et al., 1982; Rohwer & Bean, 1973).

Recently, the emphasis has shifted from task-specific strategy building to metacognitive strategies (e.g., self-monitoring) in the remedial instruction of learning-disabled children. It is possible to teach children a variety of memory strategies, but it has proven difficult to teach children to retain and transfer skills learned during laboratory learning sessions (e.g., Brown & Barclay, 1976; Underwood, 1978). In general, cognitively less mature children are less likely to continue using the instructed strategies than older children (e.g., Pressley &

Dennis-Rounds, 1980; Ringel & Springer, 1980). It has been suggested that meaningful transfer can be attained in learning of new strategies for intelligent performance only if metacognitive strategies such as goal-setting, strategy planning, and self-monitoring are trained in addition to the specific skills from which transfer is being sought (e.g., Belmont, Butterfield, & Ferretti, 1982; Bornstein & Quevillon, 1976; Brown, Campione, & Day, 1981; Kendall, Borkowski, & Cavanaugh, 1980; Moynahan, 1978; Ross & Ross, 1978).

Studies on cognitive strategy training of children may be summarized by three following issues: i) how existent cognitive and metacognitive difficulties affect children's learning and performance; ii) how the strategies, content-specific knowledge, and metacognition are interrelated; and iii) what instruction/remediation implications can be drawn from an understanding of the influences of cognitive and metacognitive strategies. One feature of training studies that should be taken into account is that it should be designed to distinguish between different possible sources of transfer failures. The instructional procedures and materials may be effectively redesigned if the reason for failure can be specified (e.g., Weinstein, Underwood, Wicker & Cubberly, 1979).

There are several limitations in studies done in the area of cognitive strategy training. First, the knowledge on a topic or availability of strategies in the individuals' repertoire have not been carefully taken into account. It has been basically assumed that the transfer test is an instance of problem solving where children can do much of the basic information processing. It has been concluded that the deliberate training of metacognitive strategies results in important gains in the ability of retarded people to solve new problems (e.g., Belmont, Butterfield, & Ferretti, 1982; Bornstein & Quevillon, 1976; Brown & Barclay, 1976; Brown, Campione, & Barclay, 1979; Kendall, Borkowski, & Cavanaugh, 1980; Ross & Ross, 1978). Some of the metacognition training studies, however, have not provided generalizations relevant to young mentally retarded children (Brown & Barclay, 1976; Brown, Campione, & Barclay, 1979). It would be essential to consider the individual differences, at the initial stage of training, in knowledge base with respect to a specific topic or availability of specific strategies for successful training of cognitive strategy use.

Second, in most of the above experimental situations, materials to be learned were presented in such a way that they restricted the subject's range of selection of strategies to one or two strategies. For a better understanding of the repertoire of the cognitive strategies of a child, it may be necessary to present the task and materials which allow children to have the greatest opportunity for flexible use of problem solving strategies. Tasks selected for this purpose should be similar to those used in natural educational settings. It would also be desirable to have tasks segmented into trials so that it is feasible to track the subject's progress toward a solution. Considering the limitations of previous studies, map reading has been suggested as an appropriate task for the study of individual differences in information processing strategies in learning (Thorndyke & Stasz, 1980).

Third, restrictions are shown not only in the learning task but also in the kinds of subjects participated in the studies on cognitive strategy. There have been extensive studies which included average and learning disabled children. Few studies included gifted children as their subjects to examine the individual differences in the use of cognitive strategies. As Weinstein and Underwood (1985) suggest, it would be necessary to identify the types of strategies used by successful learners. The information obtained from the studies which include not only average and below average but also gifted individuals would be able to provide a more complete picture about individual differences. Furthermore, understanding human diversity may be essential for the equitable treatment of individuals for the effective development of human potential.

1.1 The Current Study

The present study is designed to investigate the individual differences in content knowledge and in the use of cognitive and metacognitive strategies. The subjects comprise three different cognitive groups, -- gifted, average, and learning-disabled. The investigation of individual differences in the knowledge base in content area, the use of cognitive strategies and metacognitive strategies and map learning performances is followed by the examination of the interrelationships among these variables. The identification of the interrelationship among the predictor variables is central to the tests of individual differences in the use of metacognitive and cognitive strategies and in map learning performance. Important features of map learning tasks used in this study will be described later.

Three measures (verbal recall, spatial recall, navigation problem solving) of map learning performance were obtained. Quantitative and qualitative group differences in the use of cognitive and metacognitive strategies in map learning were examined. Map learning performances of groups with different cognitive abilities were also examined.

Group differences in content knowledge were measured by administering a test on topographic map reading skills. Two measures (frequency and kind) of specific cognitive strategies for attending to and encoding, retrieving information, and monitoring the learning performance were also obtained. The correlations between strategies, content knowledge and map learning performance were computed to examine the effectiveness of each cognitive strategy. Individual differences in metacognitive strategies were examined by computing the frequency of positive and negative evaluations of the learning performance and the use of feedback from evaluation for learning of unlearned information.

The main and interaction effects of the groups and the trials on the recall performance and strategies use were also examined by having the subjects study the same task for three trials. The relationship among the specific cognitive strategies, metacognitive strategies, content knowledge, and the learning performance were examined by correlations analysis and stepwise multiple regression analysis.

1.2 The Research Questions

1. Will there be main and interaction effects of groups and trials on the recall of spatial and verbal information from maps?
2. Will there be main and interaction effects of groups and trials on the frequency and kinds of strategies used for learning verbal and spatial information from a map? Will there be main and interaction effects of groups and trials on the use of metacognitive strategies as well?
3. What is the interrelationship among cognitive and metacognitive strategies, cognitive ability and knowledge base, and map learning performance? That is, what are the intercorrelations among those variables?
4. Which variable or set of variables will account for the

greatest variance of performance in learning verbal or spatial information? How significant are the separate influences of the predictor variables of content knowledge, specific cognitive strategies and metacognitive strategies on map learning performance?

2. REVIEW OF LITERATURE

2.1 The Gifted and the Learning disabled

2.1.1 Definitions

Over the years, there have been many studies on individual differences in terms of cognitive ability. Starting from the definition of Francis Galton (1869), much effort has been invested to identify individuals of special ability. The definitions of gifted individuals range from very broad to very specific ones. The broad defnitions are "superior ability to deal with facts, ideas or relationships" (Kirk, 1972, p.109), a very high level of academic aptitude, either demonstrated or potential (Durr, 1962) or "above average in ability, creativity, and task commitment" (Renzulli, 1978). The definition suggested for the United States Office of Education (USOE) by the Commissioner of Education (Marland, 1972) is broad and practical. It defines the gifted as "those who exhibit outstanding ability, or talent in a variety of areas -- including general intelligence, specific aptitudes, creativity, leadership, artistic ability, or atheletic talent, and who have been identified as possessing such ability by professionally qualified individuals" (Marland, 1972) such as teachers, psychologists and others with special training in the area of the child's special talent. According to the defintion by USOE, the gifted in math, for example, can be defined as those who show superior mathematical ability which is inferred from the performance on a math task. The defintion by USOE is interpreted by Gallagher (1975) as "specific identification of gifted and talented children is explicitly made a matter for professional evaluation and decision"(p.452). Gallagher (1975) suggested the most effective identification techniques include a combination of standardized IQ tests, standardized achievement tests, assessment of products or performance, and the use of rating scales that explicitly identify commonly observed performance characteristics of the gifted children.

In the opposition of the broad defnitions, are those that narrowly limit the gifted to those who perform above a specific level on a particular ability test (e.g., 130 or above on Stanford-Binet Intelligence Test). The narrow definitions guide the identification procedure, but restrict the range of children identified. One good example would be the one used in the study of mathematically and scientifically precocious youth at the Johns Hopkins University (Keating, 1974). The subjects were selected principally on the basis of their performance on SAT-M of which population mean is 500 and standard deviation is 100. On this test, the subjects obtained a mean score of 660, which is far above one standard deviation from the mean. On all other cognitive tests, covering numerical, verbal, spatial, mechanical, and perceptual functions, the selected subgroup of the top 35 cases averaged well above the norms for their age or school grade.

Although definitions of giftedness vary considerably, they all appear to conclude intellectual ability as a fundamental characteristics. Clendening and Davies (1980) state that

> Educators commonly define the young gifted and talented population as the upper 3 to 5 percent of school age children and youth who are clearly superior to their peers not only in intellectual ability but also in academic aptitude, creative and/or productive thinking, and achievement in the visual and performing arts (p.13)

Sellin and Birch (1981) indicate that intelligence is the accepted name for the combined operations of attending, thinking, remembering, forecasting, and evaluating. Alexander and Muia (1982) summarize the issue by indicating the intelligence has always been the focal point of the gifted movement.

As in the case of gifted children, the definition of the learning disabled children also has wide range of variation. The range varies from the very broad definition of learning disabled such as "those who exhibit difficulties in academic area" (Lerner, 1971) to the very specific definition as "a disorder in one or more of the basic psychological processes involved in understranding or in using language, ..., which may manifest itself in the imperfect ability to listen, think,..., or do math calculations" (USOE, 1977, p.65083). Salvia and Ysseldyke (1985) define learning disabilities more specifically as those who show "inconsistent performance" and "are likely to have pronounced patterns of academic weaknesses and strenths."(p.486)

Generally, students demonstrate nonretarded intellectual development on an individually administered intelligence testing. Salvia and Ysseldyke (1985) also suggest that the learning disabled students should demonstrate a normal range of development in some areas while demonstrating significantly delayed development in other areas of development, and demonstrate hearing and vision within normal limits. They would not have emotional problems or cultural disadvantages.

In the present study, the learning disabled in arithmetic are defined as those who have difficulty in using symbolic languages that enables human beings to think about, record, and communicate ideas concerning the elements and the relationships of quantity while they show normal range of intellectual development in other areas.

2.1.2 Characteristics of the Gifted and the Learning Disabled

There have been two major views in studying the characteristics of special children. They are psychometric and information processing views on the nature of cognitive abilities. The psychometric view assumes that intelligence consists of the possession of greater amount of latent abilities. It attemtps to measure the latent abilities quantitatively and the latent abilities identify these abilities through the statistical method of factor analysis (Furneaus & Rees, 1978; Very, 1967; Werdelin, 1958).

From the psychometric point of view, the gifted children might be seen as superior to average children in abilities such as reasoning, or spatial visualization. Laycock(1979) summarizes what systematic studies of the gifted have shown their intellectual characteristics to be as follows:

> ...superior at reasoning and difficult mental tasks; learns quickly; shows intellectual curiosity; has wide interests; reads well; works independently; shows originality; impatient with routine and drill; may show uneveness of ability and interest in academic subjects(p.57)

By and large, standardized tests can play and probably do play a valuable role in assessment, identifying children of exceptional talent and of less talent. Yarborough and Johnson (1983) conducted a survey of the procedures for identifying the gifted in 88 programs for gifted and talented in elementary and/or secondary school levels in United States. They found that 70% of the programs used combinations of IQ tests and achievement tests coupled with behavioral observations of talents in music or arts. It is concluded that the intelligence tests at least have shown sufficient validity and reliabililty for screening purposes when they are used in conjunction with other criteria (Jenkins & Friedman, 1982).

Psychometric tests, however, have limited utility in providing information about characteristics of children in terms of their learning processes. This information on characteristics is necessary to provide more appropriate educational services for the children.

Thurstone (1938) was one of the first to recognize that routine psychometric approach might obscure individual differences in solution strategy:

> When a test shows saturation with two or more factors we have no means of knowing by factorial analysis whether the several abilities enter into the test for every subejct, or whether some subjects use one ability and other subjects use other abilities for the same performance. A study ... could reveal these differences, especailly when the subjects indicate how they solve each problem (p.8).

Being consistent with Thurstone's view, the information processing approach to intelligence arose largely in reaction to a perceived failure of the psychometric approach to specify the process that constitute intelligent performance. Presumably gifted individuals would be those who are superior to others in the exercise of information processing skills such as focusing attention, encoding, retrieving and monitoring. Learning disabled individuals would be those who have difficulties in employing appropriate or effective strategies according to the task demands. Some theorists, such as Dempster (1981) or Hunt (1978) would probably emphasize the role of speed of mechanistic process execution in cognitive ability. For example, one would expect the gifted will be more rapid than the average in retrieving name codes of objects from long-term memory. Sternberg (1981a) views giftedness as attributable in large part to three information processing skills. The skills are:

1. executive processing skills, such as problem recognition, process selection, strategy selection, and so on;
2. performance componential skills, such as the abilities to make inferences and to apply previously made inferences in new domains; and
3. learning skills, such as encoding and retrieval of information that resides in long-term memory.

The interactions among these various kinds of componential skills also contribute to the superior performance. Sternberg (1984) also characterized the nature of the information processing of the gifted as "insight." The insight involves selective encoding, selective combination, and selective comparison.

Strategic behaviors of the gifted children in selecting retrieval cues have also been studied. Wong (1982) investigated organizational strategies and self-checking behaviors in selecting retrieval cues in gifted, normals, and learning disabled children. She found that the gifted spontaneously generated adaptive/efficient strategies for selecting retireval cues. The organizational strategy for selection of retrieval cues was to operate by a nonverbalized scheme. They were observed to rapidly scan the pausal/idea units of the retrieval cues. Then they examined the cards in the smaller pile ensuring the content and the number of cards of retrieval cues. Moreover, the gifted as well as the normals spontaneously engaged in self-checking behaviors and were exhaustive in their searching for the retrieval cues. In other words, the gifted showed superior metacognitive function in addition to use of more efficient strategies.

In an attempt to identify the differences between the intellectually gifted and average children, Cho (1981) studied the strategies that the gifted and the average chidren of grade 4 and 6 used in acquiring knowledge from maps over six study-recall trials. Gifted differed from the average children in encoding spatial information, evaluating their learning progress, and focusing attention on unlearned information over trials. They first segmented and focused on subsets of information from the map. They demonstrated a variety of strategies for encoding spatial information such as pattern encoding, relation encoding, mnemonics, and visual imagery. Finally, they evaluated their learning progress consistently and accurately using knowledge of their own uncertainties to determine their subsequent fixations and study behaviors. In contrast, the average used the same spatial encoding strategies but not as frequently as the gifted. The average children's evaluation was not as accurate as the gifted and they did use the feedback from the evaluation for the subsequent learning activities.

Contrary to the characteristics of the gifted, learning disabled students often exhibit ineffective thinking behaviors. Wilcox (1970), for example, has specified some characteristics of learning disabled children that may account for a breakdown in logical thinking. Among these factors are distractibility, inability to sustain attention, breakdown in continuity of thought, poor feedback, overlooking or not noticing, poor organization, difficulty in selecting, lack of resourcefulness, deficient memory. Havertape (1976) investigated the differences in problem solving between learning disabled and nondisabled junior and high school students. He found that the learning disabled group (1) did not attend appropriately to directions for completing a task and tended to be misled by irrelevant information; (2) seemed to listen attentively to directions, but either could not carry out these directions properly or did not workout to rehearse the essential information to be remembered; and (3) evidenced random response behavior or impulsive guessing in coming to a problem solution. Havertape concluded that intervention procedures should focus on teaching the adolescent to attend selectively and to respond less impulsively.

The information processing difficulties that learning disabled children experience are complex and may be a result of a number of variables (Torgesen & Houch, 1980). One of the sources of information processing difficulties in learning disabled has been found to be partly a function of production deficiency in mnemonic strategies (Morrison, Giordani, & Nagi, 1977; Tarver, Hallahan, & Kauffman, 1976).

Torgesen (1977a, 1977b) has demonstrated normal elementary school readers, when compared with learning disabled children, employed verbal rehearsal strategies which appear to be more efficient. Dawson, Hallahan, Reeve, and Ball (1980) have verified that verbal rehearsal enhances performance in learning disabled children on reading tasks. Torgesen (1977b) has proposed that reading disabled children's inefficient memorization strategies account for the often found "short-term memory" deficits and simulate the developmental performance discrepancies between the older and the younger children. This was presumed to occur because the older children have learned to plan actively, to organize, and to deploy their processing capacities more effectively than younger children (Torgesen, 1977b). Similarly, average readers appear more adept at deploying specific cognitive strategies than do learning disabled children. With instruction in mnemonic strategies, children's learning has been enhanced. For example, improvements in serial recall (Tarver, et al., 1976; Dawson, et al., 1980), paired associate learning (Martin, 1979), and memory organization (Torgesen, 1977a; Torgesen & Goldman, 1977) have been made after the mnemonic training of children with learning difficulties.

While verbal information processing plays an important role in both reading and mathematics, nonverbal thinking is crucial to mathematical learning. Kaliski (1967) has noted that many of the symptoms that identify children with learning disabilities can be related to arithmetic difficulties. Disturbances in spatial relationships have been found to be one of the major problems found in learning disabled children in arithmetic. Kaliski (1967) reported that the child with an arithmetic disability often confused spatial relationships such as: up-down, over-under, top-bottom, high-low, near-far, front-back, beginning-end, and across. Strauss and Lehtinen (1947) found that a disturbance in spatial perception interferes with visualization of the entire number system. The child may be unable to perceive distances between numbers, and may not know if the number is closer to 4 or 6.

Many children with a basic arithmetic disability are unable to see objects in groups of sets - an ability that enables others to quickly identify the number of objects in a group. Even when adding a group or a set of three with a set of four objects, some children with an arithmetic learning disability must begin by counting the objects one by one to determine the total number in the sets.

Some children are unable to visually perceive a geometric shape as an entire entity. For these children, a square may not appear as a square shape but as four unrelated lines. Because they cannot capture the gestalt of a shape and because they have disturbance in perceiving spatial relationships and in making spatial judgments, they may not be able to copy geometric forms, shapes, numbers, or letters adequately (Kaliski, 1967).

Recent attempts at understanding the academic problems of less successful learners have focused on the role of metacognitive strategies (Baker & Brown, 1980; Brown, 1980). Several studies found younger and poorer readers seem to show little comprehension monitoring, hence little metacomprehension (Baker & Brown, 1980; Forrest & Waller, 1981; Owings, Peterson, Bransford, Morris, & Stein, 1980). Deshler (1974) studied the ability of learning disabled high school students to detect errors in their performance or in the performance of others and found that on measures of creative writing, spelling, editing, and vocabulary, learning disabled students were inferior to their peers in detecting errors. Learning disabled students did demonstrate skill in detecting and correcting some errors, but they seemed to lack consistent strategies for monitoring their performance.

These problems and disturbances found in learning disabled need to be studied further, particulary, in terms of the problems in information problem solving strategies. Such future studies will be able to provide more specific information for developing instructional strategies and materials to help these children for optimizing their learning (Pressley, 1984).

In the following section the literature about the general information processing involved in problem solving will be reviewed. Then, detailed review of the individual differences in information processing variables will subsequently follow.

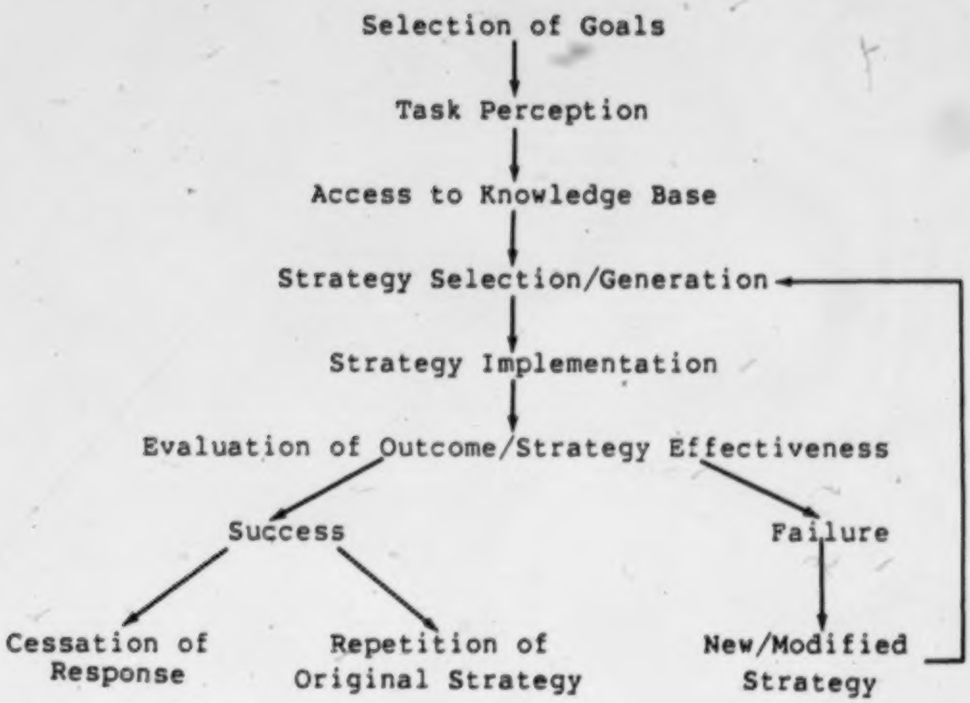
2.2 Information Processing Involved in Problem Solving

There have been various definitions of problem solving. Asher (1963) regards problem solving as the inverse of learning because it involves the process of disrupting established concepts. On the other hand, Duncan (1959) and Davis (1966) regard problem solving as a particular type of learning. And Golding (1982) argues for adopting a broad view of problem solving for research purpose, calling a task "a problem when steps or processes are detected between the posing of the task and the answer" (p.97). Similarly, Lester (1983) defines a problem as a task for which:

1. the individual or group confronting it wants or needs to find a solution;
2. there is not a readily accessible procedure that guarantees or completely determines the solution;
3. the individual or group must make an effort to find a solution.

When all three components described above are considered, the definition implies that a task requires a learner to employ complex or sophisticated strategies actively to solve the problems efficiently (Ornstein, 1978; Watkins, 1975). For example, when a recall task is given, a learner might elaborate the material so that it fits into a meaningful context or perhaps look for categories of information to help organize the material. These strategies help the learner to use his limited learning ability with improved efficiency. But the fact that strategies are used does not mean that the employed strategies are always the most effective ones for high level performance.

A general model of information processes involved in strategy use is presented in Figure 1 showing the relationship between the use of cognitive strategies, general knowledge base and metacognition. This model is an adaptation of Krasnor and Rubin's (1983) model of problem solving processes. According to Krasnor and Rubin, in the first stage of processing, the learner must access the information concerning the topic and strategies, recall and store the task requirements and constraints. After the learner has analyzed the task requirements, he will recall or construct the strategies that would presumably satisfy the task requirements. Using selected strategies, the learner will attempt to complete the task. After completion of each unit of task requirement, the learner may evaluate his own progress with the selected strategy and persist or reselect depending on the outcome of this evaluation (Krasnor & Rubin, 1983). Effective employment of one strategy would require that the learner be able to discriminate situations in which the strategy would be appropriate from those in which it would not be appropriate (Campione, Nitsch, Bray, & Brown, 1982).


Selection of Goals
Task Perception
Access to Knowledge Base
Strategy Selection/Generation
Strategy Implementation
Evaluation of Outcome/Strategy Effectiveness
Success
Failure
Cessation of Response
Repetition of Original Strategy
New/Modified Strategy

(Krasnor & Rubin, 1983)

Figure 1 - General Model of Information Processing in Strategy Use

Being consistent with this model, many other cognitive theories assume that the selection and execution of problem solving strategy depend upon an existing body of semantic knowledge and a collection of processes (e.g., Anderson & Bower, 1973; Hunt, 1978; Newell & Simon, 1972). The processes include those at the mechanistic level and high level of information processing. More specifically, controlling perceptual focus of attention, encoding new incoming knowledge, transforming the encoded information into new internal units and relationships, and integrating it with previously acquired knowledge would be included in this collection of processes. Both knowledge and processes reside in the unlimited-capacity long-term memory and can be activated and used in a limited-capacity working memory. Working memory, here, refers to that portion of long-term memory in which active processing is currently taking place and activated concepts are held.

These processes are assumed to operate in memory at varying levels of abstraction. At the lowest levels, there are mechanistic processes (Posner & Snyder, 1975; Hunt, 1978) that operate on the physical representation of a symbol and are independent of the knowledge denoted by the symbol. Such processes are either automatic (e.g., decoding a linguistic string, recognizing the meaning of a familiar words) or controlled (e.g., manipulating focus of attention on sensory channels, manipulating information in working memory). The controlled processes may be selected and monitored by learners depending upon their knowledge of and skill at various strategies. At higher levels, there are knowledge-based processes, additional controlled processes, whose use depends upon comprehension of the meaning of the information being manipulated. For example, one might decide to learn a list of words by creating semantic categories into which subsets of the words fit. To learn or recall efficiently the learner must access the information represented in some fashion in long-term memory. He cannot employ strategies efficiently unless he has the relevant semantic and conceptual knowledge of the tasks and, under some conditions, the knowledge that the implementation of strategies would be useful for problem solving.

In addition to the knowledge in long-term memory, the other major component of the memory system is operational efficiency in working memory. Working memory is also referred to as either short-term or primary memory. This is a limited capacity system from which information is lost rapidly. Retention of information cannot always be ensured unless some intentional attempt is made to maintain the information. Atkinson and Shiffrin (1968) have emphasized the importance of strategies in determining which information is entered into and retrieved from short and long term memory. Their term, "**control process**, refers to those processes that are not permanent features of memory, but are, instead, transient phenomena under the control of the subject; their appearance depends on such factors as instructional set, the experimental task, and the past history of the subject" (p.106).

The effectiveness of working memory is limited by both the amount of information being maintained and the demands imposed by the operation required for that maintenance. The more effortful the operations being carried out, the less room there is for the information being processed (Case, Kurland, & Goldberg,1982). Case and others(1983) argued that the amount of operating space required decreases as a result of an increase in operational efficiency. As less space is required for operating, more becomes available for storage. The storage space required is also directly related to the degree of organization of the to-be-remembered materials, so that more operating space is available for more information processes at a given time if the information has been organized efficiently.

The multistore (e.g., Atkinson & Shiffrin, 1968) and depth of processing (e.g., Craik & Lockhart, 1972) models differ in the mnemonic metaphors used to describe performance (See Naus, Ornstein, & Hoving, 1978; Naus & Halasz, 1979; Ornstein & Corsale, 1979), but both would consider cognitive strategies as being important determinants of the variability across individuals in memory or learning performance.

This is consistent with the results from the studies about spatial information processing. Abstraction of spatial information and inference processes may play a substantive role in people's use of representation (Bahrick, 1983; Canelos, 1982-1983; Stevens, 1976). Increased visual complexity increases abstraction time and effort (Hull, 1920) and, therefore, decreases available encoding time and space. The only compensator for this condition would be a more efficient encoding stage during information processing. The network cluster of data would also provide for established retrieval cues to facilitate the recall of information within the cluster. The retrieval cues in this case may have consisted of the superordinate information in the network of hierarchy. Additionally, once this single network of information was retrieved, the available data in this network would tend to become more accessible (Tulving & Pearlstone, 1966). The organization of spatial information must depend on the ultimate use of the stored information. Regardless of the units used, principles of hierarchical representation and reconstruction are of critical importance in the way that people encode spatial information. This view is in contrast to some recent arguments about visual representations which argue associations implicit within an image (Kosslyn, 1973; Kosslyn & Pomerantz, in press; Paivio, 1975). Simple imagery models fail to deal with the multi-levelled structuring of spatial information (Stevens, 1976).

In the following section, the literature about the influence of content knowledge, specific cognitive strategies, and metacognitive strategies on learning performance will be reviewed.

2.3 Influence of Content Knowledge on Task Performance

Although little is known about the relationship between generalized knowledge about particular topics and memory performance, Chi (1976, 1977, 1978) and Voss and his colleagues (Chiesi, Spilich, & Voss, 1979; Spilich, Vesonder, Chiesi, & Voss, 1979) have begun to explore these issues. For example, Chi (1977) attempted to determine whether developmental differences are in knowledge about stimuli, capacity of working memory, or strategy variables. By controlling the familiarity of the stimuli and the degree to which adults were able to use strategies, differences in memory span performance between adults and children were almost completely eliminated. As a result, Chi (1977) concluded that developmental differences in actual capacity of working memory were minimal and that adults' typically higher performance is the result of their greater familiarity with the stimuli and their greater facility with task-appropriate strategies.

In a subsequent study (Chi, 1978), the effects of the knowledge base were probed more deeply. Subjects were required to remember the positions of chess pieces in modified memory-span tasks. Degree of knowledge about the game of chess was manipulated by comparing a group of expert chess players with a group of relatively novice players; however, all subjects had some knowledge of chess. The manipulation of developmental interest here was the knowledge variable. The expert players were children and the novice players were adults.

Chi's data strongly support the notion that knowledge plays a critical role in memory performance. The children, who in this case were good chess players, remembered the locations of more pieces than did the adult subjects, and required fewer trials to arrive at a correct solution on the second task. To demonstrate that these effects were the result of knowldge about chess, all subjects performed memory-span tasks in which the location of digits rather than of chess pieces was probed. Results of this digit-span task were reversed from those of the chess task. That is, developmental trends were obtained, with adults recalling more digits and taking fewer trials to reach perfect recall than did the children.

Voss and his colleagues (Chiesi, Spilich, & Voss, 1979; Spilich, Vesonder, Chiesi, & Voss, 1979) investigated how individuals differing in their knowledge of a particular topic also differ in the manner in which they process this domain-related information. In this research, groups of subjects differing in their knowledge of the game of baseball were identified. The performance of high-baseball-knolwedge (HK) and low-baseball-knowledge (LK) subjects were then compared in terms of the manner in which the baseball-related information is processed, stored, and retrieved. These data suggest that although these two groups were not different in their awareness of the goal structure of the game, the performance of the subjects of HK was superior to those of LK. Specifically HK were better able to attend to and remember the information that was critical, unitize series of game actions, and monitor action and change in game "state" in the context of the goal structure. Thus, Voss and his colleagues showed that strategies such as chunking, information monitoring, and selective attention can be influenced by the degree of subjects's knowledge of the content area.

Recently, Day (1980) trained junior college students to apply the basic rules of comprehension and retention and to check that they were using the rules appropriately. Average students had no reading or writing problems identified, and rememdial students were diagnosed as having writing problems, although of normal reading ability. The general pattern of results showed that the students in the summarization training study did not seem to differ in terms of their original performance levels but the average students benefited more from instruction than did the remedial students. For the more sophisticated students, training resulted in greater use of the rules, and this improvement was effected with less instruction. For those students with more severe learning problems, the reverse pattern was shown.

On the interaction effects between prior knowledge in a topic area and student's questioning behavior, Miyake and Norman (1979) found an interaction between these two variables: Novice students in computer science asked more questions on the easy manual but very few on the hard manual. The reverse pattern of questioning behavior was obtained for the trained subjects.

The work of Chi (1978), Chiesi, Spilich, and Voss (1979), Day (1980), Miyake and Norman (1979), Spilich, Vesonder, and Voss (1979), Thorndyke (1980, 1981a, 1981b) and Thorndyke and Hayes-Roth (1980) indicates that strategy implementation and learning performance is a complex interaction of knowledge about particular topics and about particular task requirements. Probably of equal importance is the implication that the use of a cognitive strategy is not an all-or-none event. Rather it appears that the degree of availability or accessibility of certain cognitive strategies should be studied in relation to the nature of tasks and the cognitive level of subjects.

2.4 Information Processing Strategies

2.4.1 Definition of Information Processing Strategies

Information processing strategies are internally organized skills or control processes by which the learner regulates his/her cognitive behaviour (Gagné, 1977; Gagné & Briggs, 1974). One's repertoire of strategies may be seen as a set of tools that enables the leaner to acquire, retain, and apply new information effectively and efficiently (Rigney, 1978). An effective strategy has been described as the simplest and most efficient means of processing the information inherent in a situation (Newell & Simon, 1972). Similarly, Bruner, Goodnow, and Austin (1956) have defined a strategy as a pattern of decisions in the acquisition, retention, and utilization of information that serves to meet certain objectives -- that is, to ensure certain forms of outcomes and to ensure against certain others.

Gagnė (1977) distinguishes between intellectual skills and cognitive strategies. Intellectual skills refer to the repertoire of competencies that individuals develop for dealing with their environment. In addition to these, individuals also acquire increasingly skillful and somtimes complex strategies to activate and regulate important cognitive activities such as attention, comprehension, retention, and retrieval of information (Gagnė, 1977; Gagnė & Brrigs, 1974). A strategy, according to Gagnė (1974) is a skill of self-management that the learner acquires to govern the processes of learning, thinking, and problem solving. Dansereau (1978) proposed a more pragmatic definition in which a strategy was considered to be a learner-based technique that, would enable the individual to function effectively when confronted with the identification of material, the comprehension and retention of information, and the efficient coping with internal and external distractions.

From an information-processing point of view, the nature of a strategy is such that it enables a learner to form an organizational structure in which information can be stored and retrieved more efficiently (Bousfield, 1953; Bower, 1970; Mandler, 1967; Miller, 1956; Tulving, 1962). The composition of the order imposed by the learner to construct groupings or relations among the informational inputs to be learned, leads to the inference that memory is a constructive and interactive process. This process involves the learner's actively searching for contextual relationships between the input and information stored in the system in order that incoming material can be transformed and recoded into newer internal units (Gentile & Nacson, 1976).

What is it about certain strategies that make them better or worse than other strategies? Sternberg, Ketron, and Powell (1982) suggest the superiority of a certain strategy for solving problems can probably be traced to its mechanistic nature, in other words, its automaticity. In case of an algorithmic strategy for solving linear syllogisms, subjects essentially bypass the use of transitive inference by using a short cut that provides a solution. The automaticity of a strategy or the reduction in load upon working memory by employing certain strategies, thus, is the nature of effective strategies. Breuker (1984) suggested the effective strategies enable the learner to organize the hidden structure of the information into explicit form. Specifically, when learners read complicated text, networking, node-arc strategy, or pre- and post-organizers help the learners to abstract the concepts or relationships embedded in a text into a more explicit form.

An information processing strategy, in this study, is defined as the learner's active search for relationship between the input and information stored in long-term memory, so that the incoming information can be recoded and combined with previously acquired knowledge. The latter definition will serve as an orienting definition. However, the strategies used at different information processing stages, will be distinguished and defined later. The strategies for processing different type of information will also be reviewed.

In the foregoing sections, definitions of cognitive strategies have been reviewed.

2.5 Specific Cognitive Strategies

In this section, strategies used by learners to enhance their learning performance will be reviewed. The specific cognitive strategies are classified according to the stages of information processing. The stages are sampling, encoding and retrieving the information. Metacognitive strategies which function to control the use of these specific cognitive strateiges are reviewed in the next section.

2.5.1 Sampling Strategies

Generally, the strategies to identify and select information in the past has been studied by manipulating the identification and selection of stimulus information by varying anticipated recall requirements (Butterfield, Belmont, & Peltzman, 1971; Cermak, 1972) or monetary payoff conditions (McConkie, Rayner, & Mayer, 1971; McConkie, Rayner, & Wilson, 1973). These studies show that students can be flexible in their processing of incoming information but the manipulations are so task-specific that they provide little information regarding strategy effectiveness in general.

Recently, there have been extensive studies on attention as a self-regulatory process (Douglas & Peters, 1979; Gibson & Levin, 1975; Posner & Boies, 1971; Wright & Vliestra, 1975). Posner and Boies (1971) made the important distinction between general arousal, restriction of attention to task-relevant cues, and switching of attention between tasks. This distinction is especially useful in understanding the attentional demands on subjects who are perceptually sampling information from a problem solving task, when the task has a variety of perceptual features that might have to be addressed. General arousal is presumably a background process that determines whether or not and how vigilantly the subject fixates on certain information. Focus of attention refers to the process by which subjects restrict eye fixations to a particular subset of the information on the task. Gibson and Levin (1975) contend that attention includes the abilities to visually discriminate between stimuli and ignoring the irrelevant information. Attention switching refers to the process by which subjects shift their focus of attention to a new location on the task. Wright and Vliestra (1975) also asserted that attention is controlled initially by salient features of stimuli and later by logical features of the task such as memory-dicrected sampling. The individual differences in attention focusing and attention switching, however, have not been systematically investigated. This has resulted in a lack of knowledge about the nature of attention with relation to metacognition.

2.5.2 Encoding Strategies

The area of encoding strategies is the one which has been most extensively studied. There have been a number of studies on mental imagery of verbal materials (Anderson, 1970; Anderson & Hidde, 1971; Levine & Divine-Hawkins, 1974; Rasco, Tennyson, & Boutwell, 1975), verbalizing the material in the student's own words (DelGiorno, Jenkins, & Bausell, 1974), and reorganization of the incoming material (DiVesta, Schultz, & Dangel, 1973; Frase, 1973). These strategies, although somewhat effective when tried singularly, could probably be enhanced by integration with strategies in other aspects of the learning process such as metacognitive processes. In addition to these general encoding strategies, there has been a dramatic upsurge of interest in mnemonic elaboration such as method of loci, or peg-words as a specific means for enhancing retention. These mnemonic techniques involve embellishing the incoming material by creatively interrelating the items to be learned or by associating the items to previously learned set of peg words or images (Puff, 1979; Underwood, 1978; Weinsten & Underwood, 1985).

Most of these studies used lists of unrelated words and word pairs and have shown that brief instructions on mnemonic techniques dramatically improve retention (Bower & Reitman, 1972; Danner & Taylor, 1973; Lowry, 1974; Nelson & Archer, 1972; Santa, Ruskin, & Yio, 1973; Wanshura & Borkowski, 1974; Yuille & Catchpole, 1974). Although these mnemonic techniques have been successful with relatively artificial materials (nonsense syllables and unrelated words), very little effort has been made to apply these techniques to the more general problem of retaining connected discourse or to other more naturalistic tasks.

2.5.3 Retrieval Strategies

In addition to the encoding strategies, to improve a student's ability to recall information retrieval plans can be employed for accessing stored materials that are not immediately available. These plans would most likely take the form of coherent search strategies similar to those used in solving problems that have well-defined solutions (e.g., chess problems often require the search for an optimal next move). The problem-solving strategies explored by Newell et al. (1958) provide a good starting place for the development of such techniques.

Unfortunately, very little work has been done in training students to use search strategies as aids to memory retrieval. The one exception is a study by Ritter, Kaprove, Fitch, and Flavell (1973), which attempted to improve chidren's recall (e.g., systematic search strategies). The results of this study indicated that the retrieval instructions helped students to improve their recall of learned materials but the stimuli employed were so artificial (unrelated word pairs) that it is difficult to generalize the results to more meaningful tasks.

In the foregoing sections the kinds of specific strategies in each information processing stage were reviewed. In the section that follows the methods of identifying and validating cognitive strategies will be reviewed. Out of several available methods of analysis, the verbal and behavioral protocol analyses will be primarily reviewed in this study.

2.5.4 Analysis of Strategies

To identify the kinds of strategies that the subjects used for solving problems, the majority of studies have had their subjects sort or categorize and rehearse the stimulus materials when to-be-remembered items were presented to the subjects. Later, the subjects are asked to recall the materials. One method of assessing strategies is to observe the relationship between the input and the output and infer the strategies used. Some other prevalent methodologies include collecting the verbal protocols of children during their learning performance, interviewing after the learning session, or collecting self-report data about the strategies that the children have used. It is rare to assess the strategies at the output (i.e., in the actual recall of items) in terms of ordered patterns of items recalled.

2.5.4.1 Verbal Protocol Analysis

Verbal protocol analysis deals with the assessment of the subject's consciousness that more directly reflects experience than the analysis of interview or self-report. This method has been used successfully to develop and test information processing models in a variety of complex tasks such as imagery processing (Klinger, 1978), problem solving (Bhaskar & Simon, 1977; Simon & Simon, 1978), planning (Hayes-Roth & Hayes-Roth, 1978), and reading comprehension (Kavale, 1980; Miller & Goldstein, 1976).

The verbal protocol analysis attempts to assess subjects' "current thinking". A major advantage of such analysis is the sensitivity with which it can be used to address the idiosyncratic aspects of the subjects' experience. This goal is best pursued by facilitating the subjects' active participation in the measurement process. The general thrust of *in vivo* thought sampling is that it is suited to detecting qualitative characteristics of the subjects' thought processes and is appropriate for the assessment of cognitive styles or characteristic modes of cognition that subjects may bring to bear on their attempts to solve the tasks set for them by the investigator.

2.5.4.2 Strategic Behaviors Analysis

Verbal protocol analysis provides information on the strategy use of children during the study period. However, it is common for learning-disabled children to have expressive language problems (Johnson & Myklebusts, 1967; Lerner, 1971). Because of this, data collection with verbal protocol which relies on the subject's verbalization may be suspect. In general, the limitations of the verbal protocol methods are information gaps which occur when the subject forgets to talk or when s/he arrives at a conclusion without indicating the procedures that led to the articulated conclusion. Furthermore, for the nonverbal reasoner or younger children who may not or cannot verbalize, verbal protocol analysis alone may not provide enough information about their strategy use (Glass, Holyoak, & Santa, 1979).

Video recording would provide supplementary information to bridge the gap left by the requirement of verbalization. While nonverbal aspects of reasoning may not be viewed, nonverbal behaviors do provide information especially about metacognitive strategy such as use of feedback for strategy selection or switching. Exact measurement of time and clarification of implied information of verbal protocol is another benefit of video tape analysis.

Brown and Palincsar (1982) have said that a sharp distinction may be made between conscious awareness and direction of thought and their observable strategic behaviors. Although this discrepancy between verbalization and action presents a further argument for use of video it also speaks to the value of the way in which the tasks were set up.

2.5.4.3 Identification and Validation of Strategies

Several approaches have been taken in the literature to analyze the verbal protocol collected from subjects attempting to solve problems. Rather than inferring the content of the subject's covert processing, Goldin and Hayes-Roth (1980) chose to analyze only the surface content of the protocols, that is, decisions that were openly verbalized. The researchers devided the protocols into units with each segment representing a decision to identify the subjects' planning processes. In the Goldin and Hayes-Roth (1980) approach, good strategies were determined in a quantitative manner. Glass, Holyoak, and Santa (1979), in their attempt to analyze verbal protocols of problem solving, broke up the transcript into fragments that correspond to different states of the subjects' knowledge or mental activity. Then, the subjects' general approach to the problem was identified. Once that general approach was identified, the subjects' specific operations as he moved from one knowledge state to another were identified. The nature of subjects' thought processes were then described and followed by specific knowledge states and operations.

Using a concept-learning task, Bruner, Goodnow and Austin (1956) also investigated strategies. The procedure they employed consisted of three components. The first component was a verbal characterization of each strategy. The second component was an application of this general statement to a particular task by specifying a decision rule for classifying trials into subsets. The third component was an assignment rule that identifies each subset as an instance of a particular strategy. To provide validity of the strategies used by children in solving problems, however, several more steps including those advocated by Bruner et al. (1956) would be required. The specific procedures are briefly described in the following sections.

The first step requires one to produce a written characterization of each strategy to guide a reliable assessment. The description may be based upon a logical analysis of the task or upon observations of problem solvers, or a combination of these two sources of information.

The second step requires one to particularize the general description of the strategies to a definite situation by defining the procedure for identifying instances of the strategy. Ideally the procedure should be expressed as a set of rules to be applied to a behavioral record in such a way that a clear and unambiguous identification is made. This goal should be easily attainable for tasks that severely restrict the subject's freedom of action. There will be situations, however, in which it is undesirable to constrain behavior. In such cases, it is imperative to demonstrate high inter-observer reliability for identifying strategies in question.

Another consideration in the investigation of strategy concerns its stability. Implicit in the conception of strategy is the notion that it reflects a process which is not given to sudden erratic change but is a stable mode of operation characteristic of the individual. Without a demonstration of stability over repetitions of the same task, there is no assurance that even a rigorous decision procedure identifies meaningful classes of individual strategy.

The demonstration that a particular strategy identification scheme produces stable classifications is one way of establishing the validity and usefulness of a particular set of strategies. Another is predictive validity. There may be several ways in which predictive validity could be demonstrated. It can be shown by employing the original task but altering the conditions under which it is administered. One of the conditions that could be altered would be the memory load imposed on the users of different strategies. The other way would be to show that the strategy groups exhibit characteristic differences on external variables such as age, sex and/or intelligence.

In this study, all of the above procedures -- verbal characterization, decision rule, assignment rule, and stability across trials -will be applied to identify the strategies used by children.

2.6 Metacognition

2.6.1 Distinction Between Metacognitive Knowledge and Metacognitive Strategies

Individuals do have knowledge of their own cognitive activity. They can reflect upon the nature, the operation, and the outcomes of this activity. This awareness is the result of reflection that is termed **metacogntion**. There have been several attempts to delineate metacognition. Flavell (1970) uses the term "metamemory" to refer to the development of intelligent monitoring and knowledge of active storage and retrieval skills in memory. Kreutzer et al (1975) also indicate that knowledge of how to operate one's memory system involves information on a number of levels. This information consists of knowledge about particular strategies, particular task situations in which strategies best fit the task, and how one's own memory performance will relate to particular strategies. These components of metamemorial knowledge were formalized by Flavell and Wellman (1977) in terms of person variables, task variables, and strategy variables. Person variables include such things as knowledge of one's own capabilities and limitations. Task variables concern the knowledge of relevant and irrelevant dimensions of a task such as differentiating between related and unrelated materials. Finally, strategy variables concern appropriate strategies in various memory tasks which is one's own awareness of one's systematic use of efficient strategies for learning (Weins, 1983).

While Baker and Anderson (1982) refer to metacognition as "one's knowledge and control of one's own cogntive processes (p.282)", Cavanaugh and Perlmutter (1982) argue that these two aspects should be seen as distinct for purposes of research. Belmont, Butterfield, and Ferretti (1982) also distinguished metacognition into meta-knowledge and meta-processing (p.149). Similarly, Lawson (1984) suggests that executive processes are logically distinct from this metacognitive knowledge. "In being executive the individual is controlling or regulating cognitive procedures.... Nature of the executive operation may well depend upon the individual's metacognitive knowledge, but this knowledge should be seen as one source of influence upon, not synonymous with, executive processes (p. 92)." Lawson also suggests that the act of reflection upon cognition which results in metacognitive knowledge is best thought of as an executive operation. The act of reflection involves an examination of the stream of cognition - an examination that includes analysis, evaluation of progress, in terms of plans, monitoring, and modification of cognition.

To date, there has been little effort to trace the course of executive processing in more detail although verbal protocol studies (e.g., Chase & Ericsson, 1981; Lewis, 1981) show the complexity of the executive processing involved in typical problem solving situations. In the present study, metacognitive strategy will be considered equivalent to the meta-processing described by Belmont, Butterfield, and Ferretti (1982) and to executive processes detailed by Lawson (1984).

To investigate children's perception of their own memory capabilities (person variables), Yussen and Levy (1975) asked 4, 8, and 20-year-olds to predict how well they would perform on a short-term memory task. Predicted recall significantly differentiated the age groups linearly with the 4-year-olds predicting the highest recall ability. Actual recall performance also differentiated the age linearly with the adult group recalling the most items. Adults actually recalled the amount of material that they had predicted they could recall whereas the 4-year-olds fell far short of their predicted performance. Consistent with these data is Chi's (1978) demonstration that ability to predict performance is, in part, a function of knowledge of the stimuli. Using her adult expert-novice chess player groups, Chi had the chess players predict the number of chess piece positions they could recall when a legitimate chess configuration was used and when the same pieces were arranged randomly. Novices predicted the same number for random and legitimate chess configurations while experts predicted greater recall with the legitimate arrangements. In terms of actual recall, novices recalled the locations of more pieces from the legitimate than from the random configuration, although not as many as did the experts. The experts' recall paralleled their predictions. Thus, in this case, the experts were more accurate than novices in predicting their recall. Perhaps the individual differences that have been observed in recall prediction are in part due to differences in knowledge base.

In terms of task variables, Kreutzer, Leonard, Flavell (1975) showed that kindergarteners and first graders are not as aware as older children that related items may be easier to remember than unrelated ones, that interpolated events may interfere with retrieval, and that a series of pictures making a story may be easier to remember than an equal number of unrelated pictures. However, even these young children are aware that spacing of pictures should not affect recall. In a related study, Tenny (1975) asked kindergarteners and third and sixth graders to generate lists that would be easy to remember. Older subjects generated to-be-remembered lists that contained an overall explicit organization scheme (often taxonomic) , whereas younger subjects tended to free associate from one item to another in the generation of lists. These studies seem to indicate that young children are not aware of the task demands in recall.

The study of Kreutzer et al. (1975) provides normative data on strategy variables by detailing what children know about mnemonic techniques and the appropriateness of various strategies for different tasks. Consistent with the recall literature, older children plan more strategically and have a variety of internal strategies available, whereas younger children may rely on external sources such as reminders from others. It seems that older children are aware of task requirements and possess rules concerning the operation of a number of strategies. Younger children, although capable of efficient strategies (e.g., Corsale & Ornstein, 1977), may lack rules of operation which results in a failure to spontaneously employ such strategies in the recall task.

Lodico and others (1983) also found a positive relationship between metacognitive knowledge and subsequent strategy use. Second grade children were given training in general principles of strategy monitoring prior to being exposed to differentially effective acquisition strategies in a given task. The results showed that even though both experimental and placebo control groups could assess when they remembered better, more experimental than control children attributed performance differences to their strategic behavior and selected the more effective strategy on a forced-choice trial. Lodico and others (1983) conclude that instruction in general memory-monitoring principles is sufficient to effect a change in strategy usage. However, they have not investigated whether their change in awareness brings the change in their use of strategies. It is possible that even when they are aware of the effectiveness of certain strategies, they may not be able to employ those strategies.

Although much work has been done on metacognition and individual differences, an issue of critical concern is how children's metacognition relate to their knowledge on a topic area and to the procedures that they had acquired and stored in long-term memory. That is, how can childrens' metacognition be most successfully framed to facilitate high learning performances? This would seem to be a central question because, as has been illustrated above, children often do not employ the strategies spontaneously even after they have been trained.

2.6.2 Metacognitive Strategies

Studies of metacognitive knowledge and strategies are based on the view that both dimensions are critical factors in affecting performance. This is a position adopted within specific cognitive domains, such as language and memory, and across domains related to intelligence. In the literature of instructional psychology and learning disabilities, work on one or both of these dimensions is expected to provide relevant knowledge for the remediation of learning problems. However, there are not many findings of a consistent and positive relationship between either of these dimensions and performance. At present, the relationship between poor metacognitive strategy use and poor performance is more convincingly demonstrated than that between metacognitive knowledge and performance (Lawson, 1984).

Research on metacognitive strategies on executive processes has typically followed a deficiency training strategy. First, researchers have attempted to show that poor performers on a given task do not exhibit as suitable executive strategy as good performers. Good examples of these studies are available in the fields of mental retardation research (e.g., Brown, 1978) and in studies of comprehension monitoring (Baker and Anderson, 1982; Paris and Myers, 1981). In both of these cases it can be shown that poor performers do not monitor their performance or modify their strategies in ways that are appropriate for changing task situations. The second stage of much of this research, particularly in mental retardation, involves training poor performers in the use of a skill that does not appear in their current repertoire. This involved specific skills such as monitoring memory capacity (Brown, 1978) and more general, self-instructional skills (Bornstein & Quevillon, 1976). These and other similar studies have produced results, which suggest that the influence of executive processes on task performance is both significant and sensitive to instruction (see Borkowski & Cavanaugh, 1979).

However, unlikely in the case of metacognitive processes, the pattern of results of studies dealing with the metacognitive knowledge -- performance relationship is more inconsistent. This is due to confusion about the nature of metacognitive knowledge and differences in research procedure.

In several correlational studies between metacognitive knowledge and performance across a number of different task domains a weak positive relationship has been found (Cavanaugh & Borkowski, 1980; Yussen & Berman, 1981). These studies provide good examples of the inconsistency of the patterns of results. Cavanaugh and Borkowski (1980) found that while this positive relationship between metamemory and memory performance held for their total sample, it disappeared when within-grade correlations were considered. They found no significant relationship between relevant metamemory and memory performance and could not show, at the individual level, that good metameory knowledge was necessary for good memory performance. Yussen and Berman (1981) also found inconsistent relationship between metamemory and memory performance. In their study, a significant relationship between metamemory and memory performance was present for free recall tasks but absent for recognition memory.

Wong (in press) has recently pointed out the problems in the definition of cognitive strategies and metacognition. The metacognition, executive control process, may develop simultaneously or as a result of cumulative skill acquisition. Flavell (1977) also showed that strategies can be a particular activity (e.g., looking for main ideas), its monitoring function and a reflection of the knowledge about the appropriateness in using that strategy in the given situation. In this way Flavell (1977) included both of the specific and metacognitive functions into a strategy.

Other reasons of inconsistences would be lack of congruence between sets of measures. For example, a discussion of strategies to remember bringing skates to school the next day (see Kreutzer , Leonard, & Flavell, 1975) involves reflection on a task that is different from the free recall of a list of words. It should be considered whether the research procedures used do in fact constitute a fair test of the assumption.

A second source of confusion may have the root in the multiple and interactive nature of sources/factors that contribute to successful learning. Because of the interaction effects among the related factors, metamemory is a necessary but not sufficient cause of strategy transfer (Borkowski, in press). Brown's (1980) adaptation of Jenkin's (1979) tetrahedral model depicts four major sources of influence on learning outcome: (1) characteristics of the learner; (2) criterial task; (3) nature of the materials to be learned; and (4) learning activities engaged in by the learner. The literature in cognitive psychology and developmental psychology has clearly shown us how each of the sources/factors labeled governs likelihood of a student's successful learning or task performance. Since the efficiency of a metacognitive strategy interacts with a substrate of cognitive strategies for approaching problem situations, the amount of planfulness and awareness attributed to a child will depend on his level of intelligence, his learning history, the task demands, and the instructional constraints. Equally important influences on a student's successful learning are exerted by the interactions between these sources, e.g., an interaction among the knowledge of criterial task, content, strategies and learning activities (e.g., Borkowski, Peck, Reid & Kurtz, 1983; Lodico, Ghatala, Levin, Pressley & Bell, 1983; Miyake & Norman, 1979; Wong, Wong, & LeMare, 1982).

The interaction effects between the optimality of a given strategy for an individual and metacognitive proficiency on learning performance, however, has rarely been investigated. In most studies the experimenter requires learners to use certain strategies which s/he assumes to be more effective than others. The strategies may not be optimally difficult to ensure that optimal learning occurs. Sometimes the strategies may be too difficult and, therefore, ineffective for learners who cannot utilize those strategies for given problems (Lodico, Ghatala, Levin, Pressley & Bell, 1983). The lack of consideration for the optimality of specific cognitive strategies for the individual could be the reason that the effects of metacognition training have not been satisfactory with younger or mentally retarded children. Brown, Campione, and Barclay (1979) trained educable retarded children to use either of two memory strategies -- anticipation or rehearsal -- involving a self-checking component. The students were tested for generalization one year following the original training. The younger children (MA=6) showed no effects of the training on the generalization test, whereas the older group (MA=8) maintained the trained strategies. In this regard, intervention appears to lead to enhanced recall for younger groups. However, the effects of intensive training have not been generalized to other learning situations. The failure of younger students to maintain their enhanced performance on the final nonprompted test is in keeping with other studies where immature trainees abandon a trained strategy when no longer specifically instructed to continue its use (Keeney, Cannizzo, & Flavell, 1967).

It may be reasonable to assume that the strategies were too difficult and, thus, their use may not be efficient enough for the children to monitor their cognitive behavior while they are encoding the given information. On working memory, Case, Kurland, and Goldberg (1982) proposed that the operational efficiency results in a decrease of the operating space required by a task. Here, the operating space refers to the hypothetical amount of space available for executing intellectual operations. A decrease in operating space results in an increase in functional storage space which refers to the space available for storing information. The total space of working memory is assumed to be the sum of operating and storage space. If a child is required to learn a strategy which is too difficult with respect to his cognitive level, most of the operating space may have to be used merely for encoding information leaving little space to be used for metacognitive processes. The inefficiency of strategy use may result in little functional storage space available to store information again resulting in low memory and learning performance. It can be asserted that even when a strategy is known to be generally effective, the relative effectiveness of the strategy should be examined with regard to the cognitive level of a child. In other words, the child, to be efficient in problem solving, should be able to use given strategies with automaticity even when the child is able to appreciate the effectiveness of the strategy.

2.6.3 Summary

Studies reviewed to this point are characterized by at least two problems. First, the materials and tasks used to examine the manipulations have generally been highly artificial (e.g., serial and/or paired-associate lists of unrelated verbal information). This artificiality limits the possible range of generalization of these findings to educationally relevant situations. Second, specific components have been studied in isolation. They have not been integrated with other components of learning process. This lack of integration is extremely troublesome in light of the obvious interrelationships between some of the components (e.g., enhancing comprehension-retention skills will clearly have an impact on retrieval, and vice versa). A well-conceived, integrated program which considers these interrelationships should enable students to improve their learning performance much more effectively than the program which is a sum of its individual parts.

The review shows that cognitive strategy usage is closely related to knowledge on a topic area and knowledge of cognitive operations (metacognition). The training effects of certain cognitive strategies are determined by various factors such as learners' cognitive ability and knowledge level, relative difficulty of strategies, criterial tasks, materials, and also by the interactions among these factors.

Studies examining the interaction between the characteristics of the learner and learning activities have been constrained by limiting the strategies to be used and the tasks to simple artificial ones. These restrictions on the kind of strategies, tasks, and groups of learners result in little precise knowledge of the individual differences in learning performance of subjects, of the failures or ineffectiveness of strategy training programs, and of the concept of cognitive strategies and metacognition.

The majority of studies have not considered the optimality of given strategies for the individual and the repertoire of available strategies. This renders the findings from training studies more ambiguous to interpret in terms of their effects and major sources of improved learning performance. Furthermore, careful analysis of these findings would be necessary to apply the results in remediation programs for the learning-disabled.

In the present study, map learning is selected as a task for the investigation of the individual differences in strategy use and the interaction effects among on strategies file and learning performance. The map learning task has several features which are different from the tasks employed in most of the studies on cognitive strategies. First, learning a map requires apprehending and memorizing a set of named objects and places, their shapes and physical extent, and their absolute and relative relationships on the map. The learning task requires strategies for acquiring and integrating all the conceptual and spatial information given by verbal and visual stimuli on a map. Second, a map presents all the information simultaneously. The subject must decide how much time to spend studying each item and how many times to study different portions of information. In many typical learning experimental situations the map learning problem is more similar to the natural learning situation because of its complexity and flexibility. The choice of strategies will also vary depending on whether the goal is to learn verbal information or to learn spatial information (Thorndyke & Stasz, 1980). Studies on the strategies that may be used for map learning will be reviewed in the following section.

2.7 Studies on Map Learning: Theory and Research

2.7.1 Definition of Map

Since there is so much variation in the kinds of experimental maps that have been used (e.g., free Lynchian maps, overlay base maps, maps generated by preestablished languages, Gouldian aggregated preference maps), it is essential to state what is meant by "map" in this study. A map is a hybrid of linguistic and pictorial schemes (Shimron, 1975). It is symbolic in the sense that it bears resemblance to the space which it represents on only few specific dimensions. The red line which represents a highway has little similarity to the visual appearance of the actual highway. In this sense, a map is like a language with both a surface and a deep level of meaning.

Because the map represents information in a highly encoded form, the term 'reading' is applied to extracting information from maps (Pick & Acredolo, 1983). Maps, in many ways, bear a formal (i.e. projective) similarity to the thing they represent. Generally, the formal similarity between maps and the spatial layout represented is not as great as that between pictures and the aspect of the world they depict. Although we would not ordinarily speak of reading pictures, it is possible to imagine a continuum of types of representational displays of the world that varies along a continuum of encodedness along a number of dimensions. At one end there might be films and photographs; next might come X-rays, then maps, blueprints, schematic diagrams such as wiring diagrams, and ending with verbal descriptions as the most encoded form. Somewhere between pictures and maps we begin to speak of reading the display.

To the degree that there is considerable formal similarity between the representational display and the thing being represented as in the case of photographs, the perception of the represented object or layout should not pose any special problems (Hochberg & Brooks, 1962; Olson, 1976; Zimmerman & Hochberg, 1963). The fact that information in maps is more encoded than in photographs, in the sense of bearing less formal similarity to the part of the world being represented, results in map reading being a more difficult task than picture perception.

The correspondence between symbols on a map and objects and locations in the world is one place where maps can be encoded representations. Dots representing cities are examples. These are arbitrary symbols for features of the world. Some symbols are not completely arbitrary and capitalize on some projective similarity between the symbol and the class of object being represented. Examples of this would include a cross for a church and an airplaine-shaped contour for an airport. Given that a particular symbol designates a particular type object or feature it is possible to represent variations in that feature by variations in the symbol. Thus, the size of dot can be used to represent population or a city. Saturation of color can be used to represent amount of rainfall. It is possible that the dimension of variation of a symbol bears some formal similarity to the dimension of variation of the feature itself even though the symbol itself is arbitrary. For example, a dot could be used to indicate the locus of outbreak of a particular disease which would be an arbitrary symbol but the size of the dot could be used to indicate the number of cases at each locus.

The conventional map is a cultural object that may well antedate any other actual formal information storage system about the properties of the physical environment. Thrower (1972) says "It is assumed that cartography, like art, predates writing; like pictures, map symbols are apt to be more universally understood than verbal or written ones." The map is found everywhere in all cultures, among the most primitive, in purely verbal terms where it functions in mnemonic form making long-range migration possible. Among modern cultures, it inevitably exists in permanent, multiple, graphic form. The map is a cultural concretization of man's geographic, environmental thought processes. The history of cartography preserves the developmental stages of that process (Beck & Wood, 1976).

For a map to be produced, the following operations would occur: rotation, scaling, generalization, symbolization, verbalization, representation, and externalization (Thorndyke & Goldin, 1983)

Rotation -- a map represents the world rotated from the usual original field of human experience. A map is always at least orthogonal to the plane of experience. In this lies its essential utility to the organism.

Scaling -- scaling involves the representation of an experience in a size other than that at which it is experienced. The problem in scaling are many but the most critical is the maintenance of the relative size of the parts of the experience.

Generalization -- This operation is involved in the determination of what detail will be suppressed in scaling down, or what is generality lost in scaling up. Further generalization may result when the map is drawn because one cannot fit everything on it or from the principle of economy, design sense, or lack of interest.

Symbolization -- This is the process whereby the mapper "select" symbols to represent geographic features. On both mental and conventional maps, symbols are used to represent, in a type of conceptual shorthand, the complex realities of streets, rivers, mountains, oceans, etc. Conventionally, these would seem to fall into three broad groups of point, line, and area symbols.

Verbalization -- This is a process by which the mental map is labelled with place names. Specifically, the operation involves the pairing of place symbol and place name, e.g., the symbol (thick winding line) for river and the word (Thames) get placed on the map together in such a way (close, on top of) that we know that the one is part of the other.

Representation -- This is the act of "visualization" of what s/he is attempting to draw, discuss, or otherwise manipulate. This operation would be essentially conscious, so that it functions when called upon by a higher center, and that it acts as a staging for overt behaviors.

Externalization -- All of the operations take place in milliseconds, not sequentially, but with broad expanses of overlap. Furthermore, they are interconnected to each other and themselves via extensive feedback systems.

2.7.2 Studies on Environmental Spatial Information Processing

Most research on environmental spatial information processing has concentrated on investigating the relationship between the particular type of stimulus input and a particular response measure. Implicit in the vast majority of studies is the assumption that the cognitive map is a singular construct; that is, that the relationship found for one pair of dependent and independent variables is referable to this construct and, to an extent, generalizable to the relationship between other stimulus and response measures also presumed to be mediated by a hypothetical cognitive map (Gilfillan, 1982). Most studies of environmental spatial knowledge have used one of five general types of stimulus input. The types are: (1) maze experience; (2) pre-existing real world knowledge; (3) controlled exposure in a naturalistic environment; (4) controlled exposure to a laboratory produced stimulus array; and (5) controlled exposure to a symbolic representation of an otherwise unfamiliar environment or spatial array. A brief review of the major characteristics of these five general types of studies along with a typical or classic example(s) of each is presented in the following sections.

Maze Experience: These studies are characterized on the input side by motoric involvement with sequentially experienced spatial relationships and on the output side by response measures consistent with the concept that inferential constructions are formed from the explicitly presented or experienced information. This type of study is well illustrated by the experiment of Tolman (1948) and Olton (1979) who investigated the apparent ability of rats to make spatial inferences, and by implication, to form integrated cognitive maps. For example, Tolman (1948), using a walled maze, exposed his rats to several different routes to a goal. He then changed the routes available and tested his rats to determine if they would choose a new but shorter path to the goal. That is, would the animals infer the existence of spatial relationships even if the specific relationships had not been directly experienced? Many of his rats chose the novel shortcut, in a manner consistent with this hypothesis.

Pre-existing knowledge of a spatial character: The experiments of this general type do not provide external stimulus input at the time the study is conducted. Rather, experiments of this nature draw on the subjects' pre-existing knowledge of a familiar spatial environment or on the subjects' general geographical knowledge -- for example, the relative location of various cities in the United States.

Studies of this type have taken many forms and have used many different dependent measures. Lynch (1960), in a now classic study, examined people's spatial knowledge of various cities. The dependent measures which he used included a sketched map of the city in question drawn from memory and a questionnaire probing spatial knowledge. For example, people were asked how to get from one place to another. From their answer, Lynch made inferences about the salience and distinctiveness of various kinds of geographic features. He concluded from his studies that cognitive maps of cities existed and functioned primarily as orientation aids. His approach was essentially replicated for different cities by D e Jonge (1962), Gulick (1963), Appleyard (1969) and Bahrick (1984).

Controlled exposure in a naturalistic environment : Subjects are exposed to a natural environment which is novel to them (for example, a park or city) for a given period of time while they are accompanied or observed by an experimenter. At some specified time after the environmental experience, memory for the environment is assessed.

The study conducted by Menzel (1978) is a good example of an animal experiment. Menzel (1978) tested chimpanzees in an open field. The animals were carried by an experimenter who hid food in various locations in a field. The chimpanzees were subsequently released into the field and the paths by which they found the food were observed. The chimpanzees found most of the food rewards by taking the shortest route through all points even though the experimenter had not taken this direct path. The response was interpreted by Menzel as evidence that the chimpanzees had a cognitive map of the area.

Controlled exposure to a laboratory produced stimulus array: Subjects are exposed to actual objects arranged in a spatial array in a laboratory environment. A study by Hintzman et al. (1981) exposed the subjects to a circular display of eight objects positioned at 45 degree intervals. Subjects were instructed to imagine being in the center of the environment. A trial consisted of the presentation of an orientation item and a target item. The task was to point to a display indicating the angle of separation between the orientation and the target item. Both response accuracy and latency were measured. The experimenters concluded that "...cognitive maps are not holistic but consist of orientation specific representations, and, at least in part, of relational proportions specific to the object pairs." (Hintzman et al., 1981, p.149)

Controlled exposure to a symbolic representation of an otherwise unfamiliar environment or spatial array: Subjects are exposed to a symbolic representation (e.g., map, diagram, verbal description) of a spatial array not previously experienced and then tested for memory of the array. Thorndyke and Stasz (1980) used visually presented, artificial maps to assess the procedures by which people acquire information from maps. The subjects were instructed to learn the information in a map. The output variables were a sketched map, drawn from memory, and prompted verbal recall. The sketch map was scored on the relative number of correctly recalled content items and on the accuracy of item placement. Protocols taken while subjects studied the map were analyzed for process information. Knowledge of results and corrected response measures were also used. Additionally, subjects were requested to specify routes that they would take from one location to another. The present study concentrated on this category of environmental spatial knowledge using sketched maps which contain symbolic representation of spatial array not previously experienced and then subjects were tested for memory of the array.

2.7.3 Types of Spatial Knowledge

People acquire spatial knowledge from diverse types of experience: studying a map, navigating, viewing photographs, reading or hearing verbal descriptions or directions. Thorndyke and his associates have assumed that people derive three types of environmental knowledge from experiences: landmark knowledge, procedural knowledge, and survey knowledge (Thorndyke, 1980, 1981b; Thorndyke & Hayes-Roth, 1980). These types of knowledge differ in the aspects of the environment that they represent, the primary sources from which they are acquired, and the tasks in which they are most useful.

Landmark knowledge represents information about the visual details of specific locations in the environment. This knowledge presumably takes the form of perceptual icons or images of the sensory data they represent. People acquire such knowledge by directly viewing objects in an environment or by viewing indirect representations of the environment such as a photograph or film. Location recognition usually depends on the landmark knowledge. Such recognition presumably requires matching perceptual features of the current scene to representations of perceptual features stored in memory.

Procedural knowledge represents information about the sequence of actions required to follow a particular route. It includes explicit representation of points along the route where turns occur and the directions to be taken at each one. In addition, procedural knowledge implicitly represents distances along route segments, local orientation cues (i.e., directions of turns) and ordering of landmarks. This type of knowledge encodes the spatial relationship between two points in terms of the route connecting them. Procedural knowledge is ususally derived from the experience of navigating the represented route. Once acquired, procedural knowledge can be used to navigate, or to mentally simulate navigation by imagining the sequence of landmarks and turns required in travelling between two locations. Mental simulation can be useful in computing spatial relations such as estimating the distance between two points along the route or determining the direction for travel between two locations.

Survey knowledge represents the configural relations among locations and routes in an environment. This type of knowledge represents object locations and inter-object distances with respect to a fixed global coordinate system, as on a conventional map. Accordingly, survey knowledge can be acquired directly by reading a map. However, repeated navigation in an environment also leads to the development of survey knowledge (Siegel & White, 1975; Thorndyke & Hayes-Roth, 1980). Extended experience presumably allows an individual to coordinate different aspects of landmark and procedural knowledge, to make spatial inferences, and to gradually abstract the configurational relations and straight-line distances among locations from perceptually-grounded landmark and route knowledge. The map-like quality of survey knowledge makes it an efficient knowledge source for estimating straight-line (euclidean) distances and for judging the absolute relation between two locations on a fixed frame of reference.

2.8 Expected Results and Supportive Evidence

The study undertaken here is designed to determine the group differences in content knowledge, specific cognitive strategies and metacognitive strategies, and recall performance. The interaction effects of the groups and the trials on the recall performance and strategies use are also examined. The identification of the interrelationships among the use of specific cognitive strategy, metacognitive strategies, content knowledge, and recall performance is the main focus of the present study.

From the review of literature in the foregoing section, expected results and supportive evidence were found for each research questions. The specific questions to be asked in this section are as following:

1. Will there be main and interaction effects of groups and trials on the recall of spatial and verbal information from maps?
2. Will there be main and interaction effects of groups and trials on the frequency and kinds of strategies used for learning verbal and spatial information from a map? Will there be main and interaction effects of

groups and trials on the the use of metacognitive strategies as well?

3. What is the interrelationship among the cognitive and metacognitive strategies, cognitive ability and knowledge base, and map learning performance? That is, what are the intercorrelations among those variables?
4. Which variable or set of variables will account for the greatest variance of performance in learning verbal or spatial information? How significant are the separate influences of the predictor variables of content knowledge, specific cognitive strategies and metacognitive strategies on map learning performance?

The first question is about the main and interaction effects of the groups and trials on the learning performance. It is expected that the gifted, the average and the learning disabled will show significant differences in learning the spatial and verbal information from maps. As suggested by Shimron (1978) and Pick and Acredolo (1983), a map represents information in a highly encoded form and is a hybrid of linguistic and pictorial schemes. Because of the formal similarity between the map symbols and the real objects and its symbolic nature of the map, map reading is easier task than understanding abstract symbols as in language or mathematics but more difficult task than picture perception.

The characteristics of the gifted are suggested as superior ability to deal with facts, ideas or relationships by Kirk (1978) and a very high level of academic aptitude, either demonstrated or potential by Durr (1964). In contrast, the learning disabled children are suggested to show a disorder in using symbolic languages (USOE, 1977) Considering the arbitrary nature of the symbols used in the map, the gifted are expected to show the best learning performance among the three groups. The learning disabled are expected to show the least learning performance.

It is expected that there will be significant main effects of the trials. In other words, all the subjects will show increase in their learning over trials. The interaction effects of the groups and the trials are also expected to be significant. There were almost no studies which studied the learning performance over several trials consecutively. It is very difficult to obtain direct evidence of the main or interaction effects of the trials with the groups of different cognitive ability. However, indirect evidence on the interaction effects of the groups and the trials could be found in literature.

One of the main characteristics of the gifted is suggested as task commitment (Renzulli, 1978). The gifted also show a good self-checking behavior (Wong, 1982) and are accurate in evaluating their learning performance (Thorndyke & Sastz, 1981). Sternberg (1984) also suggested that the expert usually spend more time in encoding problems than the novice. The better understanding and encoding of the problem facilitate the following information processing. In contrary, the learning disabled students are known to be characterized by the inability to sustain attention, breakdown in continuity of thought, poor feedback, poor organization, difficulty in selecting (Havertape, 1976; Wilcox, 1970). Taking these differences in attention, encoding, and monitoring between the gifted and the learning disabled, they will show greater discrepancy over trials in recall performance.

The second question is about the use of specific cognitive strategies in learning attributes from a map. Human cognitive theories assume that the manipulation of information depends on an exisiting body of semantic knowledge and a collection of processes (Newell & Simon, 1972; Anderson & Bower, 1973; Hunt, 1978). The knowledge and processes residing in long-term memory are activated and used in a limited-capacity working memory. Since working memory has limited capacity, the operation efficiency determines the amount of information that can be actively processed in it (Case, Kurland, & Goldberg, 1982). The efficiency of operation may also be determined by the compelxity of to-be-remembered information and inference processes (Canelos, 1983; Stevens, 1976). Here, the strategies which can organize the material may help the learner use his limited learning ability. Efficient learner might employ complex and sophisticated mnemonic strategies (Orstein, 1978; Watkins, 1975).

It is expected that the gifted, the average, and the learning disabled subjects show differences in the frequencies and kinds of strategies. The gifted may employ more various kinds of strategies than the average and the learning disabled subjects may use the least number of different kinds of strategies. The frequency of the strategy use would also be different among differnt groups of subjects. The learning disabled subjects may not use the same strategy as often as the groups of subjects do (e.g., Torgesen, 1977; Wong, Wong, & Forth, 1977).

If certain strategies are particulary useful for learning, however, then subjects who are superior in cognitive ability to others would use those strategies than the other group of subjects (Cho, 1981; Wong, 1982). Alternatively, the average and the learning disabled subjects might use as many but less effective procedures as the gifted do (Cho, 1981; Sternberg, 1981, Sternberg & David, 1982b; Wong, 1982).

On the use of metacognitive strategies, significant group differences are expected in the frequency and accuracy of the monitoring strategies use. Several studies show that learning disabled children are not efficient throughout this domain. Series of studies by Deshler and his colleagues(1974, 1980) showed that the learning disabled adolescent are not good at detecting errors in reading comprehension. Keeney, Cannizzo, and Flavell (1967) and Wong (1982) also suggested that those who are superior in cognitive ability use metacognitive strategies more exhaustively and more frequently. The monitoring usually was studied in reading comprehension area. The studies suggested that learning disabled children are inefficient in comprehension monitoring (Baker & Brown, 1980; Forrest & Waller, 1981; Ownings, Peterson, Bransford, Morris, & Stein, 1980). Contrarily, the gifted children were found to be more accurate in the evaluation of their learning performance than the average chilren (Cho, 1981). The gifted are not only accurate in the evaluation but also use the feedback from their evaluation for the subsequent learning activities (Thorndyke & Stasz, 1980).

The group differences are also expected in strategy selection and strategy switching. Leanring disabled children may not be aware that certain strategies are more effective than other strategies for learning. This unawareness may lead the learning disabled children to use strategies inexhaustively causing abrupt terminations of strategy use. Torgesen (1977a, 1977b) found the learning disabled children do not use strategy exhaustively until they complete the learing. Rather they would terminate using one strategy even before the goal of learning is obtained.

It is possible that knowledge in topographic map reading skills give rise to better selection and use of strategies. It has been suggested that knowledge on a content area facilitates the use of cognitive and/or metacognitive strategies for learning or solving problems resulting in better learning (Chiesi, Spilich, & Voss, 1979; Spilich, Vesonder, Chiesi, & Voss, 1979). Identifying the causal relationships between the characteristics and strategy use would be beyond the limit of the present study.

To investigate the interrelationship among the variables, which are cognitive ability, specific cognitive strategies, metacognitive strategies, content knowledge, and learning performance, intercorrelations are computed. Variance of learning performance accounted for by a set of strategies or separate strategy are examined.

Newell and Simon(1972), Rigney(1978) and Tulving(1962) suggest the nature of a strategy as such that it enables a learner to form an orgnizational structure in which information can be stored and retrieved more efficiently. According to these suggestions, all strategies should be able to help learning and recall performance of learner. Other studies, however, such as Canelos (1983) and Thorndyke and Stasz (1981) show that strategies are different in terms of their operational efficiency for each individual and for the kinds of learning task.

It is anticipated that the information which is not explicitly organized will allow discerning the effecient strategies better than the information which is explicit and, thus, readily codable (see Thorndyke & Stasz, 1980). Since processing of spatial information on map requires more organization and inference processes (see Beck & Wood, 1978; Stevens, 1976; Thorndyke, 1981a) than names of objectives, it is anticipated for the recall performance of spatial information to be more highly correlated with effective strategies.

Baker and Brown (1980), Campione, Nitsche, Bray and Brown (1982), and Krasnor and Rubin (1983) contend that the effective employment of one strategy would require for a learner to be able to discirminate situations in which strategy would be appropriate from those in which it would be inappropriate. In other words, the deployment of appropriate strategies is directly related to metacognitive awareness of one's limitations and effective monitoring. Lawson (1984) also emphasized executive operation which controls and regulates cognitive processes while learning or solving problems.

It is anticipated that there will be positive correlations among learning performance, metacognitive strategies, and specific strategy use. Poor learners may fail to effectively select and use heuristic strategies following evaluations (Corsale & Ornstein, 1977; Lodico, Ghatala, Levin, Pressley, & Bell, 1983). Better performance may arise because subjects could use strategies more often (Bower & Reitmen, 1972; Butterfield, Belmont, & Peltzman, 1971; Cermak , 1972; Danner & Taylor, 1973; Lowry, 1974; Nelson & Archer, 1972; Santa, Ruskin, & Yio, 1973; Wanshura and Borkowski, Yuille & Catchpole, 1974); because they could use more effective strategies than other strategies (Canelos, 1983; Flavell & Wellman, 1977; Thorndyke & Stasz, 1980); or because they could monitor their learning progress better (Brown & Barclay, 1976; Brown, Campione, & Day, 1981; Deshler, 1974; Schmaker, Deshler, Nolan, Clark, Alley, & Warner, 1981). All of the reasons may influence learning performance of children interacting with each other.

Even though studies on individual differences in information processing of verbal and spatial information have not been systematic with regard to their requirement of mental processing, there has been much theorizing about the relationship between to-be-remembered materials and required mental processes by them. Stevens (1976) proposed three esssential properties of the spatial information processing model, which are (1) hierarchical organization; (2) inference for implicit relations; and (3) access to proper units by searching below the highest level unit.

These properties may provide a method for storing implicit information explicitly and lesser-used information in an easily inferable form. They provide a method for establishing a limited context in which to interpret other information. Once subjects use strategies for implicit information, they may process greater amount of information than when they use strategies for explicit information. This, in turn, will facilitate the use of other processing components, such as metacognitive strategies. It is, thus, anticipated that the subjects who use strategies more often to make implicit information explicit may be better in their metacognitive function. In turn, this will result in better recall performance.

3. METHODOLOGY

3.1 General Procedure

1. Screening procedures following the criteria given in the subject section were implemented.
2. After two practice trials of study-recall of map learning, each individual subject participated in three study-recall trials for each of two different maps. During the study-recall trials, when a subject was studying and reproducing maps, their verbal and strategic behavioral protocol was collected with video recorders.
3. Three study-recall trials for each of the two maps were followed by a navigation problem-solving task. It had two practice trials and three problems for each map.
4. The verbal and behavioral protocol was analyzed in terms of subjects' strategy use.
5. To identify the sampling strategies, the verbal protocol was represented with the coordinates of every landmark, hence the pattern of the shifts of attentional focus could be plotted and identified.
6. With the data obtained, statistical analyses were carried out. ANOVA's were conducted to examine the group differences in content knowledge, strategy use and learning performance. Chi squares were computed to test the differences in the number of subjects using different kinds of sampling and retrieval strategies.

Duncan's Multiple Range Test was implemented to determine the differences between any paired groups. MANOVA repeated measures were implemented to identify the changes over the repeated study-recall trials. Intercorrelations, partial correlations and stepwise multiple regression analysis were conducted to determine the relationships among the variables.

3.2 Subjects

All 52 subjects of grade 4 were selected to comprise the gifted, the average, and the learning-disabled in arithmetic groups, on the basis of the scores of the following tests.

a. Canadian Cognitive Abilities Test
b. Mathematics Survey Test by Edmonton Public School Board
c. Elementary Reading Test by Edmonton Public School Board
d. Behavioral Rating Scale for the Gifted Children by Edmonton Public School Boards

Students were chosen from 20 classes of grade 4 according to the scores on the above tests. Any children who showed emotional, perceptual, and behavioral problems were exempted from the pool of the sample. The average group was comprised of 17 subjects whose IQ scores were between 85 and 110 and whose achievement levels in arithmetic were within the range of one standard deviation below and above the mean. The learning-disabled group was composed of 14 subjects whose intelligence and reading achievement were within the same range as the average children, but whose scores in arithematic were below 15%ile. Reading decoding scores were used to eliminate the subjects who might have decoding problems. The gifted subjects were selected from those who were already in the Gifted Challenge Program established by the Edmonton Public School Board on the basis of the composite score of intelligence, achievement and behavioral rating score. All the children chosen as the gifted for this study had a mathematics scores one standard deviation above the mean. The weights given to compute the composite score for screening the gifted students by the Edmonton Public School Board is given in Appendix A. Table 1 presents the number of male and female subjects, the mean of age, verbal IQ, quantitative IQ, nonverbal IQ, mathematics achievement, reading achievement scores.

As can be seen from the Table 1, in all of the intelligence scores and achievement scores, there were significant group differences. The Duncan's Multiple Range Test showed that the gifted and the other two groups have greater differences than the ones between the average and the learning disabled group except in quantitative intelligence and mathematics achievement. Specifically, the average and the learning disabled did show significant group

Table 1. Subjects Profile

		Giftd(21)	Avrg(17)	L.D.(14)
Sex	Male	16	9	5
	Female	5	8	9
Age	Months	114.0	118.6	121.3 *
Intelligence	Verbal	134.0	107.4	91.2 ***
	Quantitative	131.0	104.6	87.9 ***
	Nonverbal	127.0	103.0	87.6 ***
Achievement	Math	57.4	49.2	36.1 ***
	Decoding	88.7	52.5	29.9 ***
	Comprehensn	94.1	53.6	24.5 ***

*** p<.0001 ** p<.001 *p<.01

differences in verbal intelligence ($t_{(49)}$=2.86, p=.006), nonverbal intelligence ($t_{(49)}$=3.18, p=.003), reading decoding ($t_{(49)}$=2.06, p=.044), and reading comprehension ($t_{(49)}$=3.08, p=.003). However, the difference was less than the one between the gifted and the other two groups (e.g., $t_{(49)}$=6.6, p=.000 between the gifted and the learning disabled; $t_{(49)}$=4.7, p=.000 between the gifted and the average group on reading decoding). Group differences in age may have been resulted from the practice of acceleration of the programs for the gifted children and repeating grades of the learning disabled children. There were 30 male and 22 female subjects. There were more male subjects in the gifted group and more female subjects in the learning disabled group. However, the difference in the number of subjects of different sex was not significant in overall ($F_{(2)(50)}$=3.11, p=.0531). On reading decoding, significant group differences were shown between the gifted and the other two groups, but not between the average and the learning disabled subjects.

3.3 Measures

Measures of intelligence, achievement in arithmetic, reading decoding, reading comprehension, and knowledge on topographic map reading skills were taken. A part of the measures served primarily as criteria of selecting subjects and the other as background information upon which further observations with respect to strategic behavior and learning performance were made.

3.3.1 Canadian Cognitive Abilities Test

1.

Canadian Cognitive Abilities Test provides three subscores on intelligence -- verbal intelligence, quantitative intelligence and nonverbal intelligence. It was developed by the Toronto Board of Education. The verbal battery is consisted of vocabulary, sentence completion, verbal classification, verbal analogies. The quantitative battery is consisted of tests on quantitative relations, number series, equation building. Nonverbal battery is consisted of tests on figure classification, figure analogies, and figure synthesis. Means of verbal IQ, quantitative IQ, and noverbal IQ obtained from the Grade 3 students in Edmonton Public School population are 108.1, 104.0 and 104.1 with standard deviation of 14.5 15.3 and 15.9 respectively.

The reliability coefficients were computed by the Kuder-Richardson Formula #20 for each subtest. The KR #20 reliability estimates was .948 for the verbal battery, .889 for the quantitative battery, and .922 for the nonverbal battery. The validity was shown in correlations of this test with the tests of educational achievement given at the same time as part of the common standardization testing. In grade 3, the achievement test given was the Canadian Test of Basic skills. The composite correlation between standard age scores on the Canadian Cognitive Abilities Test and grade-equivalent scores on the Canadian Test of Basic Skills is .85 for verbal battery, .72 for the quantitative battery, and .63 for the nonverbal battery.

3.3.2 Achievement Tests

1. Achievement in arithmetic

The Mathematics Survey Test developed and administered by the Edmonton Public School Board includes the following aspects of arithmetic skills: 4 digit numeration, fractions; facts, related sentences, problems; 3 digit addition and subtraction and problems; 1 digit multiplication and problems; multiplication and division facts, related sentences, and problems; geometry, time, money and graphing; and linear mass, capacity, temperature and area.

In Edmonton Public Schools, a revised mathematics program was introduced during the 1982-83 school year. To reflect the emphasis of the new program, the previously used Mathematics Survey Test for Grade 3 was revised and administered to all Grade 3 students in June, 1983. Even though the information on reliability or validity is not available, this test was chosen because it measures the achievement based on the current curriculum. It is reasoned to be ecologically more valid than other tests developed in different curricular and instructional context.

2. Achievement in Reading

Edmonton Public Schools Elementary Reading Test -It was developed and revised by the Edmonton Public School Board in 1978. The reading test is based on the Edmonton Public School District elementary reading objectives for Grade three. The questions used to develop the test came from three sources -- Individual Pupil Monitoring System by Houghton Mifflin Company; Primary Reading Assessment Units by the Ontario Institute for Studies in Education; and questions developed locally to assess the objectives for which no publisher test materials were available. The questions were field tested, revised, and finally normed in may, 1978 by administering the questions to all Grade three students in Edmonton Public Schools.

The Reading Decoding Test includes the following aspects of reading decoding - sight words, contextual analysis, phonic analysis, and structural analysis. Reading Comprehension Test includes vocabulary, literal comprehension, inferential comprehension, and critical comprehension. The mean and standard deviation of reading decoding test are 50.7 and 7.3 respectively. The mean and standard deviation of reading comprehension test are 57.0 and 12.6 respectively. The reliability coefficient computed by using the formula, Kuder-Richardson #20, was .932.

3.3.3 Knowledge on Topographic Map Reading Skills

The test was developed by adapting 20 items from those used in a study by Carswell (1968). A pilot study was carried out with 21 grade 4 subjects and revised in terms of the number of testing items, the degree of difficulties and topics. The testing items were accompanied by a map to which subjects can refer. Carswell's (1968) study used a topographic map of Calgary. It was replaced by the one of Florida. The latter map was selected from a book by DeBruin (1970, p.31). The map was chosen because most of the subjects were not familiar with the place on the map and the map contains diverse features. Most of the map objects were highlighted with color to reduce the time for the subjects to spend for searching for the objects. However, those objects which subjects should recognize were not highlighted. It was implemented individually and meanings of test items were clarified to the subject as much as possible. Purportedly, this test measures knowledge about determining direction, elevation, the meaning of symbols on a map, a grid system, and how to interpret the map information. (See Appendix B for the questionnaire and the reference map.)

3.3.4 Behavioral Rating Scale

The rating scale was developed in 1984 by Edmonton Public School Board based on the studies about the characteristics of gifted children. Edmonton Public School Board administered the rating scale only to those children who were nominated by the teachers and principals to participate in the Gifted Challenge Program. Teachers were asked to observe and rate children's behaviors whether they demonstrate general intelligence, creativity, leadership, curiosity, task commitment, reflectivity, independence, realistic evaluation ability, and fluency in problem solving. The rating scale is composed of 15 items with the range from "0" (never) to "5" (always). (See Appendix A for a copy of the Behavioral Rating Scale)

3.3.5 The Experimental Tasks

The tasks included reproduction of two maps. Each map was reproduced three times with the help of either a spatial or verbal cue. Following the latter, subjects were asked to solve three navigation problems for the movement on the route. While subjects were trying to learn the information from the maps, their verbal and behavioral protocols were collected with video recording equipment. Their strategic behaviors of sampling, encoding, and retrieving of information, and monitoring of their learning progress were analyzed by playing the recorded video tapes repeatedly. The navigation problems were given after the study-recall trials of map reproduction had been completed. The presentation order of the maps and the cues were counterbalanced to minimize the effects of the presenting order and interaction between maps and cues.

3.3.5.1 Maps

Two fictitious maps (Town map and Countries map) were adapted from a study of Thorndyke and Stasz(1980). The maps were presented on the monochrome screen of the microcomputer, which controlled the map viewing time for study section to one minute per trial. The viewing time was limited to one minute. This time restraint was placed because the pilot study suggested that it required too much time for subjects to complete the experiment before becoming tired. Because of the time constraint, the number of objects and names were reduced and the names were also replaced by more familiar and easily readable ones through a pilot study. The Town map, 20cm x 16cm, portrays streets, buildings and other typical landmarks. The Countries map, 16cm x 20cm, differed from the Town map in both scale and content. The latter portrays countries, cities, roads, and prominent terrain features. Some of the elements of the maps, except some roads and railroads, have verbal names. In constructing the maps, a variety of types of map features were presented to include the named and unnamed elements, and to make the maps as natural as possible. The Town map contained 30 spatial elements, 14 of which had names. The Countries map contained 35 spatial elements, 15 of which had names. During the recall session, either verbal or spatial cues were given to reduce the difficulty level of the learning task and to shorten the time taken for the completion of entire experimental procedure. Spatial cues were given by providing a map with all the spatial information, but with no labels on it. Subjects were asked to recall and write down all the labels of the map elements. Visual cues were given by providing a list of names of landmarks under the outline of the map. Subjects were instructed to fill in the blank spaces by drawing the spatial elements of the map. (See Appendix C for the Town map and Countries map)

3.3.5.2 Navigation Problem Solving

The problems were presented by having circle move along certain routes on the map displayed on the screen. The computer program for the navigation program was written in BASIC. The navigation problems were developed and revised through a pilot study. To enhance the legibility of the movement of the circle, the size of the circle was enlarged from 2 mm to 5 mm and the speed of the movement was slowed down from 1.5 cm/sec to 1 cm/sec. The routes and time lengths of the navigation varied from simple to complicated ones and short (7.4 seconds) to long (22.1 seconds) ones. The subjects viewed a screen for 13.6 seconds on the average at the speed of 1cm/sec. After viewing the movement of the circle, the subjects were instructed to tell the experimenter how to reach the target point from the starting point. Three problems for each of the two maps were given. The problems required the subjects to integrate, sequence and recall the landmarks, intersections and the instant direction of the movement on the route. For example, one such problem for the town map requires subjects to specify the route, intersections and directions in which the circle moved along and buildings it passed in traveling from apartment building to gas station (See Appendix D for the routes of the navigation problems, computer program of the circle movement and the scoring sheet)

3.4 The Experimental Procedure

After two practice trials, three study-recall trials on one map were followed by another three study-recall trials on another map. The subjects were tested individually. Each subject was asked to study a map presented on the screen of a micro computer for one minute. During the study trial, s/he was also asked to "think aloud" whatever s/he was thinking about.

Two practice trials on a simpler map (County map) than the task maps were given to familiarize each subject with the study-recall procedure, task demands and "thinking aloud" procedure. They were encouraged to practice "thinking aloud" their strategic behaviors. After one minute of study, the map automatically disappeared from the screen. S/he was asked to reproduce the map on the answer sheet which provided either verbal or spatial cue. The time for recall was not limited. Each subject continued to the next study trial by pressing the space bar of the micro-computer after s/he finished the recalling.

After all the study-recall trials, each subject was given navigation problems. Two practice trials were followed by three problems for each map. The subject was shown the circle moving along a certain route on the map. After the display went off, the subject was asked to tell how to reach the target point from the starting point. After the answer, the subject pressed the space bar to continue to the next problem. Answers were recorded and transcribed for scoring. Subjects were given two practice trials on the County map to familiarize themselves with the circle and the movement. (see Appendix C for the practice map and answer sheets with different cues.) During their practice trials, it was clarified that they were required to tell not only the landmarks but also the directions and important junctions.

After the completion of the navigation problem solving, they were tested on the Topographic Map Reading Skills after an interval of half an hour in order to avoid the effect of boredom. For each individual it took 45 to 50 minutes to complete the entire experimental procedure. (The instruction given during the experimental sessions is in the Appendix E)

3.5 Analysis of Data

3.5.1 Scoring of Map Reproduction

For scoring the subjects' reproduced maps, units of information called "elements" were defined. An element was a map symbol representing a physical and/or conceptual entity, such as building, road, country, lake or park. Each element can have two attributes -- verbal label and spatial location. The location of an element is defined relative to the adjacent landmarks (e.g., a building located at the intersection). The spatial attributes of one or two dimensional element (e.g., a street or country) include its shape and location with respect to adjacent elements

Recall of spatial and verbal information was scored independently according to the kind of cues given. Relative position of map elements placed were considered for scoring the recall of spatial elements. The examples of the answer sheets with different cues are in Appendix C. To increase the validity of scoring the spatial elements were scored in terms of the absolutely or relatively correct placements. The absolutely correct placement was identified by comparing its original location and that on the reproduced map. If the element was located within 1 cm from the original location, it was given one point for its absolutely correct placement. For the elements which were not placed absolutely right, the relative placement with respect to its adjacent landmarks were examined with the number of adjacent elements taken into account. Examples of the scoring sheets for absolutely and relatively right placements are given in Appendix C. The number of opportunities for absolutely and relatively right placement of labeled spatial elements of Town map were 14 and 47 and those of unlabeled spatial elements were 30 and 98 respectively. The percentage of correct spatial recall was computed by applying the formula which takes the relative placement into account. An example of the formula for computing the spatial recall score for the Town map is given below:

$$S = (La/14 + Lr/47 + ULa/30 + ULr/98) \times 100$$

Where, S is the total score of spatial recall
La is the absolutely right placement of labeled element
Lr is the relatively right placement of labeled element
ULa is the aAbsolutely right placement of unlabeled element
ULr is the relatively right placement of unlabeled element

3.5.2 Analysis of Strategy Use

The verbal and behavioral protocols collected from six study-recall trials were analyzed following the approaches of Glass et al (1979) and Goldin and Hayes-Roth (1980).

Even though nonverbal aspects of reasoning may not be viewed, nonverbal behaviors provided information especially on their retrieval and monitoring strategies. Exact measurement of time and clarification of implied information of verbal protocol was another benefit of video tape analysis. Brown and Palincsar (1982) have said that there is a sharp distinction made between conscious awareness or direction of thought and their observable strategic behaviors. Although this discrepancy between verbalization and action presents a further argument for the use of video recording, it also speaks to the value of the way in which tasks were set up.

Based on the data obtained in the form of verbal and behavioral protocol, the strategies were identified and validated. Identification and validation procedures of strategies described in Chapter 2 were applied to identify and validate strategies after the segementation of the verbal protocol. Four general types of information processing strategies were identified and operationalized prior to the experiment by analyzing the learning protocol of pilot subjects -- sampling, ~~encoding,~~ retrieval and monitoring. Specific decision rules in scoring the sections of the protocols were applied. The decision rules are described in the following section. When ambiguous cases arose, the scoring options were discussed until there was a consensus between measurers, and then the decision criteria were refined. The protocol was segmented into sections such that each individual section mentions a property of a particular map element, a relationship between two or more elements, an intention to perform a certain action, or a comment on the study process itself. Each section was then evaluated to determine which, if any, strategy it represented. The stability across trials for each strategy was also used as a criteria. Only those strategies used more than twice by a subject were considered for the analysis of group differences in the frequency of the strategy use and the proportion of users of each strategy.

To identify sampling strategies, all the map elements mentioned in the verbal protocol were converted to numbers which represented their coordinates on the map. The numbers were transferred to an APL file in the form of two dimensional matrix according to the sequence in the verbal protocol. Then they were plotted on the Hewlett Packerd -- 2647A Graphics terminal and the 2671G printer plotter. Up to 12 to 15 data points for the shifts of attentional focus were used for plotting. These "plots" were visually analyzed to identify the patterns and sequences of the focus movement.

The retrieval strategies were identified by analyzing the drawing of the subjects during the recall session. The experimenter recorded the sequence of drawing of map elements. Numbers were assigned for each unit of the map segment for the convenience of tracking down the sequence of the map elements drawn. Each unit of map elements defined for the scoring of the reproduced map was assigned a number. Two different series of numbers were assigned separately for the labeled and for the unlabeled spatial elements. The numbers assigned to each map element increased from north to south and from west to east. The numbers for the labeled spatial elements were identified by closing the numbers into parenthesess. Two different drawing patterns in the sequencing of map elements were found throughout the pilot study -- separate retrieval of individual elements and retrieval of the mainframe first. All the drawings were categorized into these two strategies.

In the following section, the definitions and examples of each strategies. There were several strategies that were used for each level of information processes of sampling, encoding, retrieval and monitoring.

3.5.3 Operational Definitions of Information Processing Strategies

3.5.3.1 Sampling Strategies

There were three different patterns in sampling information from the map: random, systematic, or regionally-focused. Generally, each subject employed one sampling strategy consistently. However, some subjects switched sampling strategies from one to another kind, but a major sampling strategy for each subject was identified for each study session.

1. Random Sampling. The subjects shifted the attentional focus around the map, with the new focus seemingly independent of the previous focus in both content and location. There was no specific or distinguisable pattern that could be named. Attention moved to objects which were located in a far distance, then to another objects in the other side. It sometimes moved to the adjacent objects but soon to another object in a far distance.
2. Systematic Sampling. The subjects continued to move their attention to adjacent objects in one direction forming some patterns such as oscillating or spiraling. When oscillating, the attentional focus continuously shifted to and fro between two points like a pendulum, but with a changing angle. When spiralling, the focus wound continually and advanced as if along a cyclinder. (Examples of the oscillating or spiraling pattern is given in the Appendix F)

    The subjects also shifted the attentional focus relating some elements of a map to a reference point that they chose. Reference points could be a distinguishable object in a map, either because of its location, meaning of the names or shape. Focus of attention recurred to the reference point after each search trip to other area. This sampling pattern was identified whenever there was a repetitious recurrence to certain map elements.

3. Regionally Focused Sampling. This sampling strategy was memory-directed. Focus of attention was limited to a certain area (e.g., Northwest of a map). Using this sampling strategy, the subjects attended certain elements more often. This type of sampling was selected for a reason: subjects evaluated they had not learned information in a certain area and decided to learn it. In these cases, the subjects focused their attention on a certain area in a map and concentrated on learning information only in that area. Reading information around and then fixing their attention on a certain area was also classified as the regionally focused sampling.

3.5.3.2 Encoding Strategies

These strategies were categorized according to the type of information encoded. Encoding of three different types of information (verbal, spatial, and relational information) was found.

1. Verbal Encoding Strategies

Three verbal encoding strategies were observed.

a. *Kinesthetic encoding*. The subjects used their finger or pencils to trace or point names rather than just reading them with their eyes only.

b. *Counting*. The subject enumerated the elements sharing a particular property (e.g., "There are five places and two lakes.")

c. *Rehearsal*. The subjects repeated a set of element names in the protocol. The repetition of an element name or a set of names consituted the instance of rehearsal (e.g., "cecil, juno, cecil, juno, cecil, juno")

2. Spatial Encoding Strategies

Six strategies were observed for encoding spatial information.

a. *Kinesthetic Strategy*. As in the verbal kinesthetic strategy, the subjects used either finger or pencil to point or trace the spatial elements of a map.

b. *Recognition*. The subjects made statements indicating recognition of the existence of a certain spatial elements (e.g., "line there, "line there").

c. *Labeling*. The subjects generated a geometrical term for a complex spatial configuration. For example, a subject might notice that Eastern three roads on the Town map formed a triangle and several squares at the bottom of the map. The scorer judged a protocol to contain this strategy whenever a subject named a geometrical shape such as "triangle" or "square" to refer to the relationship between two or three elements on the map (e.g., "That's a triangle." -- referring to three roads meeting each other.)

d. Elaboration. The subjects described individual lines, or configuration of spatial elements. For example, a subject might notice a straight line or zigzag line in the Countries map. The scorer judged a protocol to contain this strategy whenever a subject described about the individual configuration of a spatial element (e.g., The line goes straight down and turns east")

3. Relation Encoding Strategies

a. Individual Relation. The subjects verbalized of a spatial relationship between two or three elements. Subjects recognized the relative position of elements using relational predicates such as "between, above, by", etc. For example, a subject stated that "Bode lake is below the Great lake". The arguments to these predicates were either element names or a location defined by the intersection of two roads or railroads.

b. General Relation. The subjects described the relationship between a map element and the entire map. One example is "Bode lake is at the bottom."

3.5.3.3 Retrieval Strategies

The third type of process evident in behavioral protocol was retrieval strategies. Two different strategies were identified

1. Retrieving main frame first. The subjects started drawing the main roads of the map first, and then completed it by drawing the rest of the details. It was determined through the analysis of the records of their drawing in terms of the numbers given to each spatial map elements as described above, evidenced by the consecutive numbers of the unlabeled spatial elements first. Then, the numbers for the labeled spatial elements followed (e.g. 1,2,3,4,5,7,9,10,11,12,13, (3), (4), . . (7), (13).... Note that the numbers in the parentheses refer to the labeled elements and the numbers without parentheses refer to the unlabeled elements).
2. Separate retrieval of the individual elements. The subjects drew the labeled spatial elements (mainly cities and buildings) first and then the unlabeled spatial elements (mainly roads and railroads)

later. The strategy was identified whenever the numbers were not consecutive in the beginning of the drawing and the parenthesesed and unparenthesesed numbers were mixed. (e.g., 3,(5), 4, (1), 9,(8), 10, 13, 19, 15,(15), 21.....)

3.5.3.4 Monitoring Strategies

3. Positive and Negative Evaluation. Subjects monitored their learning progress by considering what they had already learned and what they still needed to study. In particular, the subjects evaluated elements in the current focus of attention to determine whether or not they had learned them well enough to recall them later. Any statements indicating that the subject did or did not know particular elements or categories of elements was representative of this procedure. This evaluation required a search for and retireval of the memory representation, comparison of them to the same information on the map, and a decision about whether the two were equivalent. (e.g., "I got that." or "Oh, that was Gambia. I could not remember it.")

4. Task Evaluation. Monitoring procedures were also observed in task evaluation when subjects stated whether the task was difficult or easy for them. The unit of task could be the whole map, total verbal or spatial elements, or one element of a

map. When they found that it was hard to recall certain elements they would concentrate on studying those elements exclusively (e.g., "Names are pretty difficult.")

5. Cues Utilization. Monitoring was be observed in their use of given cues as well. The subjects crossed out the names after drawing the corresponding spatial elements with labels and checked whether they had exhausted all the information or not. In some cases these cues were used to help retrieval of the information from their memory. However, the fact that they used cues after they drew the corresponding spatial information with labels showed that the subjects used them for monitoring. In other words, they utilized the cues to check whether they had learned a certain information or not.

However, given spatial cues, subjects also used them to recall verbal information. The subjects checked all over the map to find out whether there were any more spatial elements that should be labeled, after they wrote down the labels on the spatial elements which had names. (see Appendix G for a Strategy Assessment Sheet.)

3.5.4 Reliability of Strategy Identification and Scoring of Map Reproduction

To establish the reliability of the identification of strategies and the scoring of reporduced maps, point-by-point agreement ratio (Kazdin, 1982) was used. Whether raters agreed on the category of the strategy that a verbal segment represented is assessed for each segment. The scoring of the raters for each segment was compared directly to see whether both raters categorized the segment into the same strategy. Rather than considering the total number of strategies per one study trial, agreement was evaluated on a segment-by-segment basis. The formula for computing point-by-point agreement consists of :

$$\text{Point-by-point} = A/A+D$$

where, A is the agreements for the segment
D is the disagreements for the segment

To compute the intra-rater reliability, a scorer assessed the protocol from six study-recall trials for one subject. With a time interval, the same protocol was assessed again and computed the reliability using the point-by-point agreement ratio. The intra-rater reliability computed in this way was r=.92.

Inter-rater reliability between two scorers was computed by assessing the strategies in three protocols. The protocols were randomly selected and each protocol contained the statements of a subject during the six study-recall trials. During the pilot study, the second scorer was trained on the categorization of strategies using the definitions and rules established on the basis of the review of literature. The second scorer was instructed to learn the operational definitions of each strategy and follow the rule of segmenting and categorizing the strategies. The inter-rater reliability computed by the point-by-point agreement ratio was r=.81. The segments where there were disagreements between two scorers on the kinds of strategies that the segments represented were considered to refine the operational definitions and rules of the categorization of the strategies. The inter-rater reliability computed after the clarification and refinement was r=.87.

The intra- and inter-rater reliability for the scoring of the reproduced maps were computed following the same manner. Rather than considering the differences in the scores given to each map element, the occurrences of agreement and disagreement of the score given to each element were counted. To compute intra-rater reliability, three reproduced maps by three different subjects were scored twice with time interval and the number of occurrences of agreements and disagreements was counted. Using the point-by-point agreement ratio, the intra-rater reliability ratio computed was r=.87. The inter-rater reliability was also computed following the same manner as in the case of the strategy identification. Two scorers assessed 18 maps reproduced by three subjects during the six study-recall trials. The inter-rater reliability computed by the same point-by-point agreement ratio was r=.78. When the map elements where the two scorers did not agree were closely analyzed, it was found that most of them were unlabeled spatial elements. To improve the reliability, the scores to be given for the relatively correct position of the unlabeled spatial elements were clarified. After the clarification of the criteria for scoring of the unlabeled spatial elements, the inter-rater reliability increased to r=.84.

3.6 Statistical Analysis

3.6.1 Chi Squares

To determine the group differences in the number of subjects who used each strategy, Chi squares were computed. Since the stability of the cognitive activities is essential for the learning activities to be considered as strategies, only those who used each strategy more than twice through out the six study-recall trials were used for the analysis. For the use of sampling strategies, behaviors of all the subjects were categorized into three different strategies -- random, systematic, and regionally focused sampling strategies. The numbers of subjects using each of these sampling strategies were compared between groups. The use of retrieval strategies was also analyzed as in the case of the sampling strategies. There were two different retrieval strategies identified to separate retrieval of individual elements and organized retrieval. The cognitive behaviors of subjects were categorized into two of these retrieval strategies.

3.6.2 ANOVA

In order to examine the pooled group differences in the frequency of strategy use, knowledge on map reading, and learning performance, oneway ANOVA was undertaken. The UANOVA program developed and revised in the University of Alberta was used to carry out the ANOVA. Here the independent variable was cognitive ability (i.e., gifted, average, and learning disabled in arithmetic). Measures of learning performance and strategy use computed for intercorrelation analysis were used. That is, dependent variables were the three measures in map reproduction and the variables on specific cognitive strategies and metacognitive strategies which were measured as the number of occurrence of the strategy in a subject's entire learning protocol.

To determine the differences between two paired groups in the frequency of strategy use, knowledge on map readng, and recall performance, Duncan's Multiple Range Test was carried out. In the result section, the pooled variance estimates by this test for differences between two paired groups are reported.

To identify the main and interaction effects of the groups and the trials, the repeated measures were also carried out. Within Subject Factorial Analysis of 3 (groups) X 3 (trials) ANOVA was implemented using SPSSx program. The scores of spatial and verbal recall, the frequency of each strategy use, the proportion of the strategy users for each trial were dependent variables. Three trials for each map and the group were the independent variables.

3.6.3 Intercorrelations

Intercorrelations among the variables (ability variables, knowledge on map reading skills, observed strategies, and map learning performances) were computed to ascertain the interrelationship among them. The total numbers of occurrence of each strategy on two maps across six study-recall trials were computed. And mean percentages of recall performance of verbal, spatial and total attributes were computed.

Three measures of learning performance were used: mean percentage of spatial attributes correctly recalled per trial, mean percentage of verbal attributes correctly recalled per trial, percentage of correct answers on navigation problems, and knowledge on map reading skills. The other following variables are of the strategies which were identified either as cognitive or metacognitive strategies through the protocol analysis. All of these variables on strategy were measured as number of occurrences of the strategy in a subject's entire learning protocol from video recordings.

3.6.4 Partial Correlations

Partial correlation coeffecients were computed to partial out the effects due to intercorrelations among the variables. Only those variables which are significantly correlated with the dependent variables, even after the confounding effects were partialed out, were chosen to be used for the stepwise multiple regression analysis.

3.6.5 Stepwise Multiple Regression Analysis

A stepwise multiple regression analyses were carried out to find the best predictor or a set of predictors of learning performance. Three criterion variables were used: mean percentage of correct recall of map elements; mean percentage of correctly recalled verbal elements; and mean percentage of correctly recalled spatial elements. Predictors were number of occurrences of each strategy computed for intercorrelation analysis, including sampling, encoding, retrieving information and monitoring strategies and the scores on topographic map reading skills. The stepwise was used because the subset of strategies that would be predictive of performance might not be identified *a priori*. With this analysis, the order in which variables entered the regression analysis and their contributions to cognitive group variance were identified. The variables entered into the analysis constitute the set of indenpendent predictors of subject performance on the learning task.

4. RESULTS AND DISCUSSIONS

This study was undertaken to explore the findings suggesting that use of specific cognitive strategies and metacognitive strategies and knowledge base influence the recall performance. The study investigated:

1. group differences in the recall of verbal and spatial information from maps, in the navigation problem solving and in their progress in recall;
2. group differences in the strategy use, change in the strategy use over study-recall trials;
3. interrelationship among the recall performance, cognitive and metacognitive strategies, and the content knowledge;
4. the variable or the set of variables which account for the most variance in recall performance.

Three groups of different cognitive abilities were included in the study. Fifty two subjects comprised 21 gifted, 17 average, and 14 learning disabled students were selected based on the scores of intelligence, mathematics achievement, and reading decoding. Both males and females were included. The experimental tasks included reproducing maps and solving navigation problems. Knowledge base was measured by a test on topographic map reading skills. Strategy analyses were carried out on the basis of the verbal and behavioral protocols collected during six study-recall trials. To identify the individual differences in recall and strategy use, ANOVA, Duncan's multiple range test, and Chi squares analysis were carried out. The significance of main and interaction effects of trials and groups were tested by carrying out repeated measures analysis. Interrelationship among the cognitive strategies, metacognitive strategies, and knowledge base was analyzed by computing intercorrelations, partial correlations, and stepwise multiple regression analyses.

Even though intelligence scores of average and learning disabled subjects were in the same range, the means of intelligence subscores were significantly different. To check the effect of intelligence on group differences between the average and the learning disabled in dependent measures, ANCOVA was carried out on only the variable which was significantly correlated with any of the IQ scores. Only spatial recall was found to be significantly correlated with quantitative intelligence. The result of ANCOVA revealed that the covariate(i.e., quantitative IQ) is not a factor that differentiates average from learning disabled subjects. Summary of all the statistical analyses are presented in the Appendix H.

4.1 Recall Performance

4.1.1 Map Reproduction

The town map contained 42 spatial elements, 14 of which had names. The countries map had 35 spatial elements, 15 of which had names.

For each subject, the proportions of verbal elements with correct spelling only, correct placement only, or both correct spelling and correct placement were calculated. The proportions of the labeled spatial elements and that of the unlabeled spatial elements were also calculated on the basis of absolutely and relatively correct placement of each element for each trial. The examination of the individual variation in performance was based on the scores from the last trials only.

The mean recall of map elements of all the subjects was consistent across the two different maps and was significantly correlated with each other (r=.33, p<.001). The recall of spatial and verbal information were also significantly correlated with each other (r=.33, p<.001). On the average, the subjects learned slightly more spatial information (48.9%) than verbal information (46.7%).

Across all the trials, subjects recalled spatial information with names (62.5%) better than spatial information without names (35.4%). The result is consistent with other studies that show superior memory for labeled over unlabeled spatial information (e.g., Pezdek & Evans, 1979).

Figure 2 and Table 2 present the group differences in the recall of verbal information and labeled and unlabeled spatial information in terms of the percentage of the correctly recalled elements at the last trial. The group differences were further analyzed by Duncan's multiple range test. In recalling verbal, spatial and total elements, significant differences were found between the gifted and the other two groups. The gifted recalled significantly more verbal information than the learning disabled subjects ($t_{(49)}$=3.14, p=.003). Compared with the average subjects, the gifted recalled some more verbal information. The group differences, however, were not significant ($t_{(49)}$=1.87. p=.068). In recalling spatial information, gifted subjects were significantly superior to both the learning disabled subjects ($t_{(49)}$=3.08, p=.003) and the average subjects ($t_{(49)}$=3.15, p=.003). There was no significant difference between the average and the learning disabled subjects in the subscores of recall. The learning disabled subjects showed less recall than the average group subjects except in recalling the labeled spatial information.

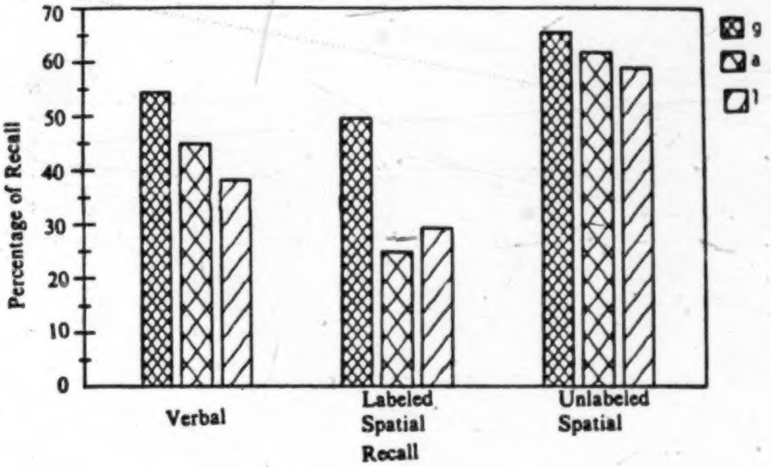


Figure 2. Percentage of Correct Recall of Verbal, Spatial and Total Map Elements for the Last Trial

Table 2
Percentage of Correct Recall for the Last Trial

	gifted(21) Mean (SD)	average(17) Mean (SD)	L.D.(14) Mean (SD)
Verbal	54.3(14.0)	44.9(18.4)	37.6(13.3)**
Spatial	57.5(16.8)	43.3(11.5)	42.9(10.7)**
Labeled	65.5(17.4)	61.9(15.7)	58.6(12.8)
Unlabeled	49.5(20.6)	24.8(13.1)	27.2(13.3)***
Total Recall	55.8(11.4)	44.1(12.9)	16.9(8.5)**

*** p<.001 ** p<.01 * p<.05

4.1.2 Group Differences in the Progress of Recall

A repeated measures analysis of univariate ANOVA was carried out to determine the main and the interaction effects of three groups and three trials on the recall performance. Figure 3.1, 3.2, 3.3 and Table 3 present the learning progress in terms of recall of labeled spatial, unlabeled spatial, and verbal information. As expected, there was a main effect of the trials in recall ($F_{(2)(88)}=58.05$, $p<.0001$ for spatial recall and $F_{(2)(88)}=235.07$, $p<.0001$ for verbal recall). There were interaction effects between the trials and the groups in verbal recall ($F_{(4)(88)}=6.14, p<.0001$), but not in the spatial recall. In verbal recall, the increase of the gifted was rapid between the trial 1 and 2 and it slowed down between the trial 2 and 3. In contrast, the ones of the average and the learning disabled maintained almost similar rate over trials.

The interaction effects between the groups and the trials were analyzed further in terms of the recall of the labeled and the unlabeled spatial elements by repeated measures analysis. Over trials, the group differences became greater in the recall of the unlabeled spatial information ($F_{(4)(88)}=2.09$, $p=.088$) than in the recall of the labeled spatial information ($F_{(4)(88)}=.22$, $p=.92$). As can be seen in Figure 3.1, the gifted showed rapid increase in verbal recall between trial 1 and 2 and slower increase between trial 2 and 3. Whereas the learning disabled showed no change in the increase over trial 1, 2, and 3. On the recall of the unlabeled spatial elements, as can be seen in Figure 3.3, the gifted subjects' recall increased slowly between trial 1 and 2, and increased rapidly between the trial 2 and 3. Meanwhile the average subjects' increase in recall of the unlabeled spatial information slowed down between the trial 2 and 3 and the learning disabled subjects showed a similar speed in the progress.

The gifted showed contrary trend in the increase of recall of verbal information and unlabeled spatial information over trials. Whereas the average and the learning disabled showed minimal differences in the increase trend.

This finding could be due to the differences in the encodibility of verbal and unlabeled spatial information. The verbal information is already coded into symbols which are used everyday. The unlabeled spatial information is not explicitly organized (Pick & Acredolo, 1983). It should be organized into more explicit form. Since the encoding of the unlabeled spatial information requires more elaborate information processing than the verbal information, the subjects may have to spend more time on encoding the unlabeled spatial information for better learning (see Breuker, 1983). Sternberg (1984) proposed that although greater intelligence is associated with more rapid

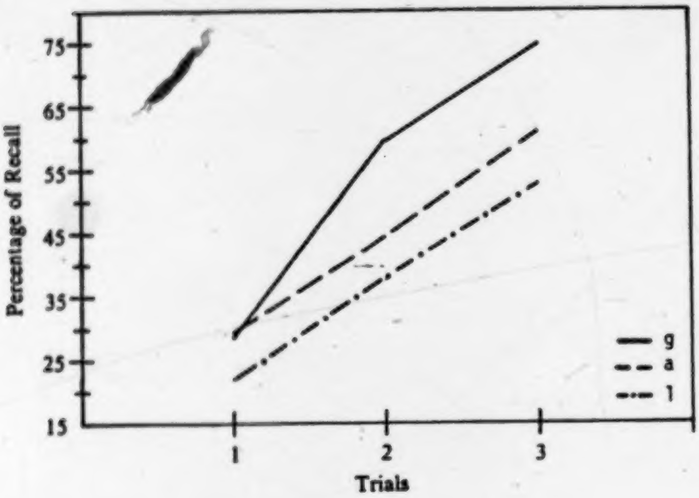


Figure 3.1
Percentage of Correct Recall of Verbal Information over Trials

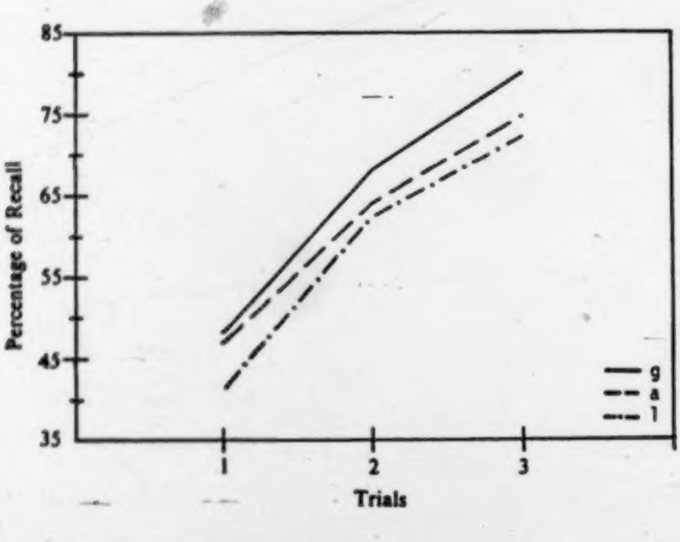


Figure 3.2
Percentage of Correct Recall of Labeled Spatial Information over Trials

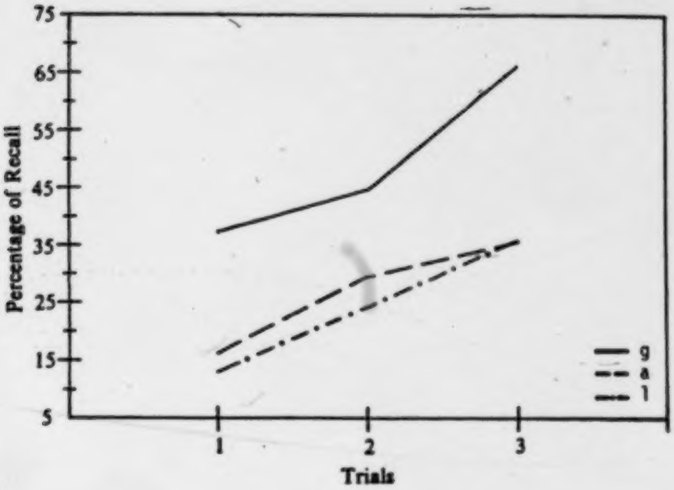


Figure 3.3
Percentage of Correct Recall of Unlabeled Spatial Information over Trials

Table 3
Mean Percentage of Correct Recall over Trials(%)

	Trial 1 Mean (SD)	Trial 2 Mean (SD)	Trial 3 Mean (SD)
Verbal Information			
Gifted(21)	28.7(13.3)	59.4(18.0)	74.6(17.8)***
Avrge(17)	29.4(16.5)	44.4(20.7)	60.8(20.8)***
LD (14)	22.0(8.9)	38.0(15.1)	52.7(17.3)***
Labeled Spatial Information			
Gifted(21)	48.3(19.0)	68.2(20.7)	80.1(19.4)***
Avrge(17)	47.0(22.3)	64.1(19.1)	74.7(12.8)***
LD (14)	41.2(20.1)	62.4(13.7)	72.2(11.3)***
Unlabeled Spatial Information			
Gifted(21)	37.4(22.1)	44.7(22.4)	66.3(25.3)***
Avrge(17)	16.3(10.9)	29.6(14.6)	35.7(19.7)***
LD (14)	13.1(10.1)	24.3(17.0)	36.1(18.6)***

*** p<.0001   ** p<.001   * p<.05

execution of most components of information processing, problem encoding is a notable exception to this trend. Sternberg and Rifkin (1979) found that an intelligent individual tends to spend relatively more time encoding the terms of the problem, presumably to facilitate subsequent operations on these encodings. The above finding was supported by other studies (e.g., Mulholland, Pellegrino, & Glaser, 1980; Sternberg, 1977).

A one way ANOVA was carried out to determine the differences among the three groups on the verbal recall with different kinds of errors. Figure 4.1 and Table 4.1 present the mean verbal recall of correct spelling only, correct placement only, and both of the correct spelling and placement across the trials.

The repeated measures analysis of 3(groups) by 3(trials) ANOVA was carried out to determine the main and interaction effects of the groups and the trials on the verbal recall with different kinds of errors. The group differences are summarized in Table 4.1 in terms of the mean number of verbal elements recalled either with correct spelling only, correct placement only, or both. As can be seen in Figure 4.1 and Table 4.1, there was a significant main effect of groups in recalling verbal information with both of right placement and right spelling ($F_{(2)(48)}=7.05$, $p<.005$), but not in recalling either right spelling only or right placement only. Duncan's Multiple Range Test showed that the gifted were significantly better in recalling

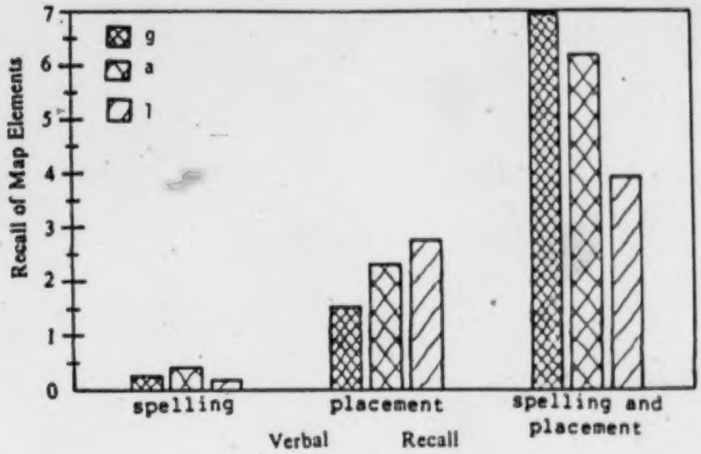


Figure 4.1
Correct recall of Verbal information across Trials
(No. of elements)

Table 4.1
Number of verbal elements correctly recalled across trials
with different errors

	Gifted(21)	Averge(17)	LD (14)
Spelling only	.32	.43	.24
Placement only	1.56	2.33	2.83*
Spell & Place	6.95	5.10	3.95**

** p<.01 * p<.05

verbal elements with right placement and right spelling than both the learning disabled subjects ($t_{(49)}$=3.66, p<.0001) and the average subejects ($t_{(49)}$=2.32, p=.025).

Figures 4.2, 4.3, and 4.4 and Table 4.2 present the mean number of recalled verbal elements with correct spelling, correct placement, and both of the correct spelling and both of the placement for three different groups respectively. The main effect of the trials were significant in verbal recall with both correct spelling and correct placement ($F_{(2)(98)}$=137.9, $p<.0001$) but not in verbal recall with either kind of errors.

The interaction effects of the groups and the trials were also significant on the recall of verbal information with both correct spelling and correct placement. The increase of the recall of the gifted subjects was the greatest ($F_{(2)(40)}$=82.46, $p<.0001$), then the average subjects ($F_{(2)(32)}$=32.75, $p<.0001$) and the learning disabled subjects ($F_{(2)(26)}$=24.42, $p<.0001$). The interaction effects of the groups and the trials on the verbal recall

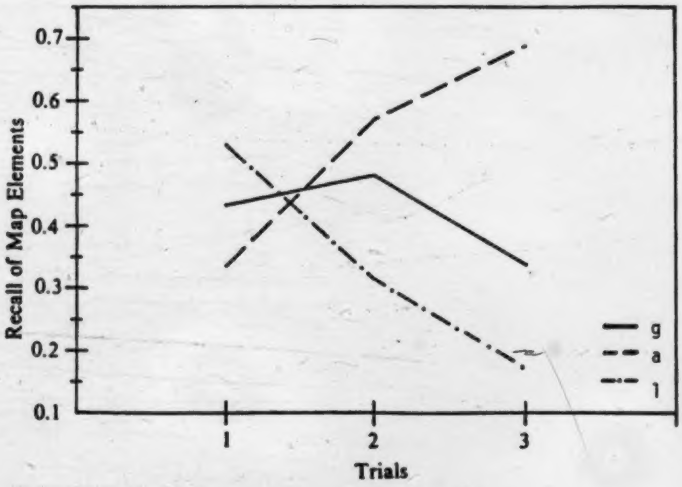


Figure 4.2
Number of Verbal Elements Recalled with Correct Spelling over Trials

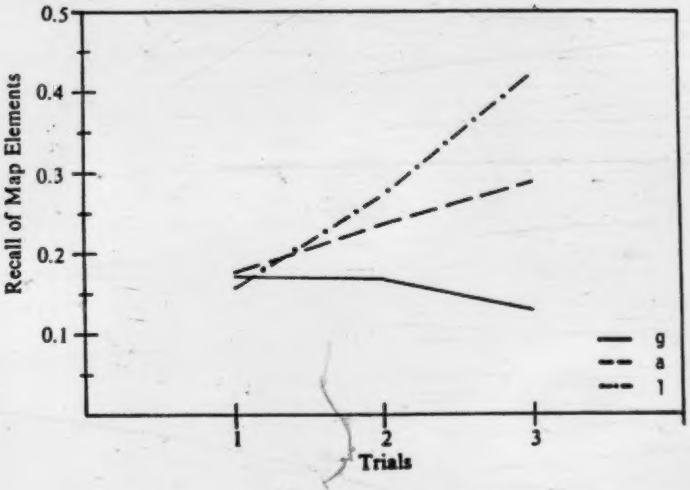


Figure 4.3
Number of verbal Elements Recalled with Correct Placement over Trials

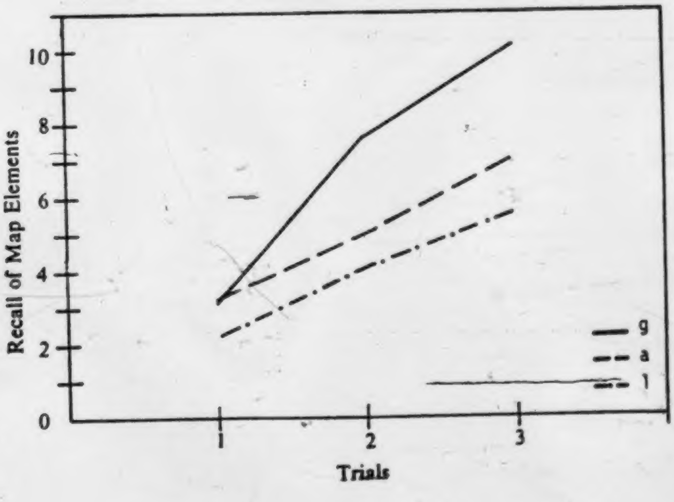


Figure 4.4
Number of Verbal Elements Recalled with Correct Spelling and Placement over Trials

Table 4.2
Verbal Recall with Correct Spelling, Correct Placement or Both over Trials (No. of elements)

	Trial 1	Trial 2	Trial 3
With Correct Spelling			
Gifted (21)	0.33	0.38	0.24
Average (17)	0.24	0.47	0.59
LD (14)	0.43	0.21	0.07
With Correct Placement			
Gifted (21)	1.71	1.67	1.29
Average(17)	1.76	2.35	2.88
LD (14)	1.57	2.71	4.21***
With Correct Spelling and Placement			
Gifted (21)	3.14	7.62	10.10***
Average (17)	3.23	5.00	7.06***
LD (14)	2.21	4.07	5.57***

*** p<.0001 ** p<.001 *p<.01

with spelling error but with correct placement was significant ($F_{(4)(98)}=5.75$, $p<.0005$). The recall of verbal information with wrong spelling significantly did not increase for the gifted and the average subjects, but it significantly increased for the learning disabled subjects over trials ($F_{(2)(26)}=14.73$, $p<.0001$).

4.1.3. Navigation Problem Solving

In Navigation Problem Solving, the subjects were asked to show how the small circle reached the target point from the starting point following the route of a small circle moved on the map presented on the computer screen. This task required such processes as paying attention to the relevant information only and remembering the important reference points along a certain route (e.g., intersection where the circle made a turn), integrating several map elements simultaneously in addition to recalling verbal and spatial attributes.

The overall group difference in problem solving was examined by one way ANOVA. There was a significant main effects of groups ($F_{(2)(49)}=14.75$, $p<.0001$). The mean score of Navigation Problem Solving of the gifted, the average, and the learning disabled subjects were 37.3, 24.5, and 23.1 respectively. Standard deviations of the scores of the gifted, the average and the learning disabled were 11.0, 6.3, and 7.3 respectively. The differences between any two groups were examined by the multiple range test. The results showed that the score of the gifted was significantly higher than both the average subjects ($t_{(49)}=4.5$, $p<.0001$) and the learning disabled subjects ($t_{(49)}=4.7$, $p<.0001$).

The performance on the Navigation Problem Solving also showed a significantly high correlation with the percentages of spatial recall ($r=.37$, $p<.005$) and with that of verbal recall ($r=.37$, $p<.005$). This significant correlation may contribute in resolving the arguments about the validity of using map reproduction as a measure of problem solving because of its requirement of drawing skill and simplicity. If the recall of verbal and spatial information were significantly correlated with the Navigation Problem Solving scores, the reproduction of the map also could be a valid measurement of problem solving ability. The problem requires not only recalling the information from the map, but also organizing and integrating several map elements simultaneously. This finding is consistent with other studies (Thorndyke & Goldin 1983, Thorndyke & Stasz, 1980) suggesting that the good map learning performance is correlated with navigation problem solving.

4.2 Information Processing Strategies

In the analysis of learning protocols, four general types of processes employed by the subjects during the study sessions were identified: sampling, encoding, retrieval and monitoring. All of these processes were evidenced in the protocols of the subjects. Each of the process categories entails several individual strategies that are components of the high level process. Table 5 summarizes the processes and possible strategies that were used for that level of information processing. The first column presents each stage of information processing. The second column presents subprocesses at each stage. The third column shows the actual strategies that were employed by the subjects to learn information from a map. The fourth column presents the number of the subjects who employed the strategies more than twice throughout the six study-recall trials and the fifth column presents the mean frequency of the use of strategies.

The strategies with the most frequently used ones being the first are rehearsal, individual relational and general relational encoding strategies, recognition of the spatial elements, labeling and elaboration of spatial information. However, some of the strategies were employed more than 50 times across the different cognitive groups and some of the strategies were used only by a certain group of subjects. Though it would be beneficial to analyze all the observed strategies, only the ones used by more than 3 (5.8%) subjects are reported and discussed.

In the following section, the group differences in terms of the number of subjects who used each strategy more than twice, total frequency of the strategy used throughout the study-recall trials, and changes in the strategy use over three trials, were analyzed. The order of presentation of strategies follows the one shown in the Table 5.

4.2.1 Group Differences in Strategy Use

To examine the group differences in the use of strategies and performance, the protocols of the gifted, the average and the learning disabled subjects were contrasted. There was a significant difference between the gifted and the other groups in the number of different kinds of strategies used. On the average, the gifted, the average and the learning disabled subjects used 7.2, 4.8 and 3.6 different kinds of strategies respectively. The Duncan's

Table 5
Number of Subjects and Total Frequency of Strategy Use

Process	Sub process	Strtgs	No. of Subjects	Frequency
Attention				
	Sampling			
		Random	7(13.5)	*
		Systematic	36(70.7)	*
		Regional Foc	8(15.7)	*
Encoding				
	Verbal			
		Kinesthetic	12(23.1)	1.0
		Counting	7(13.5)	0.4
		Rehearsal	51(98.1)	143.4
	Spatial			
		Kinesthetic	13(25.0)	1.5
		Recognition	24(46.2)	3.9
		Labeling	17(32.7)	2.3
		Elaboration	22(42.3)	3.4
	Relation			
		Individual	27(51.9)	8.9
		General	19(36.5)	3.8
Retrieval				
	Drawing			
		Separate	41(78.9)	*
		Main Frame	11(20.9)	*
Metacognition				
	Monitoring			
		Positive	13(25.0)	1.3
		Negative	19(36.5)	2.0
		Task	6(11.5)	0.4
		Cues Utlztn	20(38.5)	1.1

Note: Numbers in the parentheses represent the percentage of the subjects.

Note: For the use of sampling and retrieval strategies in each study-recall session, all the subjects were categorized into the kind of subcategories multiple range test showed that the gifted subjects used significantly more kinds of strategies than the average subjects ($t_{(48)}$=2.74, p<.0001) and more than thelearning disabled subjects ($t_{(48)}$=3.84, p=.009). Among subjects of different groups, there were significant differences in the number of subjects who used each strategy and the frequency they used it. The major differences in each of processes are summarized in the following section.

4.2.1.1 Attention

The first stage of information processing includes the attentional processes required for the perception and sampling of the physical map. Posner & Boies (1971) distinguished three components of attention: general arousal; restriction of attention to task-relevant cues; and switching of attention between information. It is important to distinguish these three different stages of attention. In this study, strategies in focusing on and switching attention between information were analyzed.

Sampling strategies determined the sequence of shifts of a subject's focus of attention among map elements. There were three different patterns in sampling information from the map -- random, systematic, or regionally-focused. These three sampling strategies were invoked in any learning trials.

A few subjects used random sampling strategy. These subjects shifted the focus of attention haphazardly around the map with the new focus seemingly independent of the content and location of the previous focus. These subjects did not show existence of plan or purpose to learn either new or learned information.

The majority of the subjects employed the systematic sampling strategy. The subjects continued to move their attention to the adjacent objects according to some patterns such as oscillating or spiraling. The oscillating movement is indicated by a movement of back and forth along one direction and spiraling by circling around some points and spreading either in or out at the same time.

Some of the subjects sampled the information from the maps by using the strategy which is characterized by the regionally focused attentional movement. They divided the map into several areas. They shifted the attentional focus to a certain area and aimed at particular objects that they had realized that they could not remember in the previous recall session.

As described in the Methodology chapter, the use of sampling strategies were analyzed only for the second and the third trial of each map. The Chi square analysis was carried out to determine the group differences in the kind of sampling strategies that the subjects used in each trial.

Figure 5.1 and Table 6.1 present the percentage of subjects who used each of the sampling strategies across the trials. A significant group difference was shown in the use of sampling strategy ($X^2_{(4)}=13.51$, $p<.01$). As can be seen in the figure and the table, the gifted subjects did notnot use the random sampling strategy, while the average and the learning disabled subjects used it. Most of the gifted used the systematic sampling strategy and the rest of the gifted used regionally focused sampling strategy. Whereas a few percent of the learning disabled used regionally focused sampling strategy.

A repeated measures analysis of univariate ANOVA was carried out to examine the main and the interaction effects of the groups and trials on the number of subjects who used sampling strategies. Figure 5.2, 5.3, and 5.4 and Table 6.2 present the proportion of users of sampling strategies over trials for each group. Table 6.3 presents the main and the interaction effects of the groups and the trials on the proportion of users of sampling strategies over trials.

Significant main effect of groups was found but the main effects of trials or the interaction effect were not significant. The result shows that the subjects did not change their sampling strategies over trials and consistently used a certain kind of strategies. Even though the main effect of trials was not significant, some change in the kind of sampling strategies the subjects used was observed. The gifted and the average subjects showed similartrends in selecting sampling strategies over trials. Whereas the learning disabled showed a contrary trend to those shown by the gifted and the average subjects.

Specifically, the number of subjects in the gifted and the average who used systematic sampling strategy increased as the trials were repeated, whereas the number of the learning disabled subjects decreased from the second trial to the third trial.

A similar trend was shown in the use of the regionally focused sampling strategy. The number of the gifted and the average using the regionally focused sampling strategy increased, while that of the learning disabled subjects decreased over trials.

The finding is consistent with the one by Thorndyke and Stasz (1980). The good performers used systematic and memory-directed sampling strategies. They started searching for the items that they could not remember in the previous recall session and then concentrated on studying those unlearned information. Whereas the poor performers recognized the unlearned information but did not show an intention of learning them. In using random sampling strategy, there was no change in the number of the gifted and the average subjects, while the number of the learning disabled subjects decreased from 38.5% to 23.1%.

In summary, most of the subjects used systematic sampling strategies throughout their study trials. They shifted their attentional focus trying to encode the names or spatial configuration of spatial elements until all the elements in the map had been considered. Nevertheless, the regionally focused sampling strategy was also used during the last trials when subjects had learned the majority of map information and had only ~~a~~ part of the map information to learn. When using the regionally focused sampling, the subjects concentrated on the elements in a certain area.

To determine the main and interaction effects of the sampling strategies and the groups, 3 (sampling strategies) by 3 (groups) ANOVA was carried out. The dependent variables were the percentage of total correct recall. Table 6.4 presents summary of two way ANOVA results. Significant main effects of strategies and groups were found on total recall. Interaction effect of the sampling strategies and the groups was not significant. The finding suggests that the gifted used the sampling strategies that resulted in better performance.

The difference in the selection of sampling strategies use is attributable to the use of metacognitive strategies. Canavaugh and Permutter (1982) and Lawson (1984) suggested the function of metacognitive strategies as analysis, monitoring, and modification of cognition. The efficient learners switched the sampling strategy according to the feedback from the evaluation of their recall performance in the previous trials. Those learners who used the regionally focused sampling strategy might have been searching for the unlearned elements in order to focus on them. In this case, the use of sampling strategy was goal-directed. This inference is based on speculation.

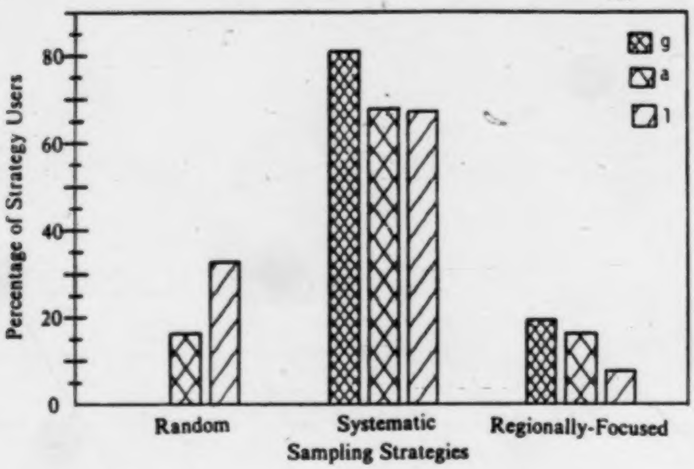


Figure 5.1
Sampling Strategy Use: Proportion of Subjects across Trials

Table 6.1
Sampling Strategy Use: Proportion of Subjects across Trials

	Gifted(21)	Average(17)	L.D.(14)
Random	0.0	16.2	30.8
Systematic	81.0	67.8	53.9
Regional	19.1	16.2	7.7

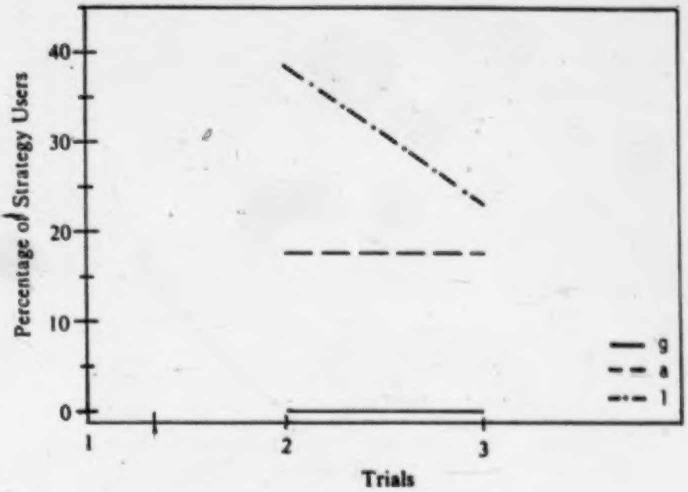


Figure 5.2 Random Sampling Strategy over Trials: Proportion of Users

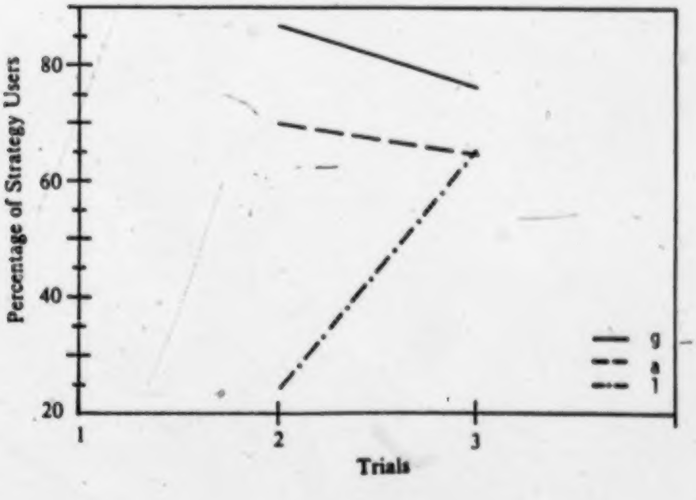


Figure 5.3 Systematic Sampling Strategy Proportion of Users

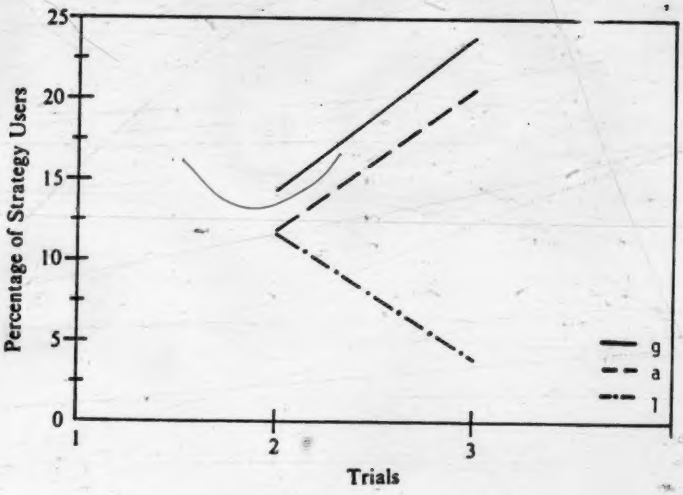


Figure 5.4 Regionally Focused Sampling
Proportion of Users

Table 6.2
Proportion of Users of Sampling Strategy

	Trial 2	Trial 3
Random		
Gifted	0.0	0.0
Average	17.6	17.6
L. D.	38.5	23.1
Systematic		
Gifted	86.8	76.2
Average	70.0	64.7
L. D.	23.9	65.4
Regionally Focused		
Gifted	14.3	23.8
Average	11.8	20.6
L. D.	11.6	3.9

Table 6.3
Main and interaction effects of the groups and the trials on the use of sampling strategies

Sources	MSH	MSE	F	df	P
Group vs Cases	6.25	0.66	9.40	2/48	0.0
Trials vs TxC	0.48	0.57	0.83	1/48	0.3
G X T vs TXC	0.20	0.57	0.35	2/48	0.7
Cases	0.66	0.57	1.15	48/48	0.3
Trial X Cases	1.15				

Table 6.4
Main and interaction effects of the sampling strategies and the groups on total recall

Sources	MSH	MSE	F	df	P
Smpling Strt	1824.1	508.8	3.58	2/45	0.036
Groups	2981.4	508.8	5.85	2/45	0.005
S X G	128.0	508.8	0.25	1/45	0.062
RESID	508.8				

4.2.1.2 Encoding Strategies

When information was in a subject's focus of attention, various encoding strategies were required to maintain it in his working memory, to encode and to elaborate it in long-term memory and to integrate it with other learned information. These strategies may be categorized according to the type of information encoded. Encoding of three different types of information, (verbal, spatial and relational), were identified.

Verbal encoding strategies operated primarily on semantic and linguistic information, such as the names of buildings or roads. The subjects used the kinesthetic strategy. They used their fingers or pencils to trace or point to the names of map elements. To remember a set of names, some subjects used the counting strategy. They clustered several elements ~~sharing a~~ particular property and counted the number of the elements of a common character. Almost all the subjects used the rehearsal strategy to encode verbal labels. Rehearsal was used to transfer the information from short term memory to long term memory by repeating a name or a set of names without elaboration or association. The use of other strategies for verbal encoding was minimal.

Four strategies were observed for encoding spatial information -- kinesthetic, recognition, labeling, and elaboration. The most widely used strategy is recognition, which does not require for the subjects to relate the spatial elements either to the other elements or to their previously acquired knowledge.

The next most widely used strategy is elaboration. The subjects paid attention to the shape or the direction of the individual line. They described the individual line in terms of the shape or direction such as "zigzag" or "going straight down"

Some subjects employed the labeling strategy. These subjects noticed the geometrical relationship among the roads and used such geometrical terms as triangle or square to label the particular part of the spatial elements.

To trace the spatial configuration, some subjects used not only their eyes but also their kinesthetic sensation. Hence, the information might be registered through multiple channels of the organs. The latter was used the least by the subjects out of four different spatial strategies.

Two different kinds of strategies for encoding relationships were identified. Relation encoding strategy refers to the verbalization of a relationship among the map elements or between the map elements and the map framework. The strategy for encoding the relationship among the map elements was used by more subjects and more frequently than the strategy for encoding the relationship between the map elements and the general map framework. To relate individual map elements to each other, the subjects used predicates. To relate a map element to the general map frame work, they used the concepts which represent overall relationships such as center or east.

4.2.1.2.2 Group Differences in Encoding Strategies

The subjects did not show much differences in the strategy used for encoding verbal information. The gifted subjects used various spatial encoding strategies frequently while the average and the learning disabled subjects did not. The gifted subjects encoded the spatial location, the relationship, and/or the configuration by explicitly elaborating and labeling them. Significantly fewer subjects of the average and the learning disabled used these strategies. Even the latter subjects used the encoding strategies significantly less frequently than gifted students. In general, the repertoire of spatial encoding strategies was smaller than that utilized by the gifted subjects.

To identify the group differences in the proportion of the subjects who used each strategy, the number of subjects who used one strategy at least twice throughout the six study-recall trials were calculated. The significance of the group differences in the ratio of user and nonuser of each strategy were examined by Chi squares analysis having the number of users and the non-users as the dependent variable and the results of the significance are presented in Figure

6.1, 6.2, and 6.3 and Table 7. In terms of the proportion of the subjects who used each encoding strategy, there were significant differences only in spatial elaboration strategy ($X^2_{(2)}$=5.52, p<.001) and strategy for encoding relationship among individual elements ($X^2_{(2)}$=6.42, p<.05). More of the gifted used verbal kinesthetic strategies than the average and the learning disabled subjects ($X^2_{(2)}$=5.52, p=.06). The differences, however, were not significant. There were also differences in relating map elements with general map framework ($X^2_{(2)}$=5.27, p=.07) but the differences were not significant either.

In addition to the number of subjects who used each strategy, group differences in total frequency of each strategy use across trials was also examined. A one way ANOVA was carried out to determine the group differences in the frequency of strategy usage. The overall frequencies were calculated by adding the frequencies across the six study-recall trials for each group. Figure 6.4, 6.5, and 6.6 and Table 8 present the mean of the total frequency of the strategy use for encoding verbal, spatial, and relational information respectively during the six study-recall trials. The result showed a significant group effects in the frequencies of using the spatial kinesthetic ($F_{(2)(48)}$=~~4.46~~, p<.05), spatial elaboration ($F_{(2)(48)}$=8.97, p<.001), and general relationship ($F_{(2)(48)}$=4.62, p<.01) strategies. Among these strategies, only the spatial elaboration strategy was used by a significantly different proportion of the subjects in each group. The other two strategies were used by similar percentage of subjects but the gifted subjects used more frequently.

This result is consistent with the studies contending inefficiency rather than deficiency of the strategies use as characteristic of the learning disabled. Gerber (1983) noted that learning disabled are not necessarily strategy deficient (i.e., the absence of strategy use). Rather, they are strategy inefficient or strategy inflexible. Borkowski and Buchel (1983) have also suggested that poor results may be attributed more to inadequate or inappropriate instruction than to the child's deficiency.

The differences between any two groups in the frequencies of strategy usage were further analyzed by using the Duncan's Multiple Range Test. Table 9 presents the summary of the results. The gifted and the average subjects showed differences in using the verbal kinesthetic strategy ($t_{(48)}=2.45$, $p<.05$), but the differences were not shown between other groups. In verbal counting, the gifted and the learning disabled subjects showed significant group differences ($t_{(48)}=2.61$, $p<.02$). These two were the only verbal encoding strategies where the subjects showed group differences in terms of the frequencies of the strategy use. In spatial encoding strategies, the gifted subjects used kinesthetic strategies significantly more frequently than the average ($t_{(48)}=2.65$, $p<.015$) and the learning disabled subjects ($t_{(48)}=2.32$, $p<.030$). Spatial recognition was used

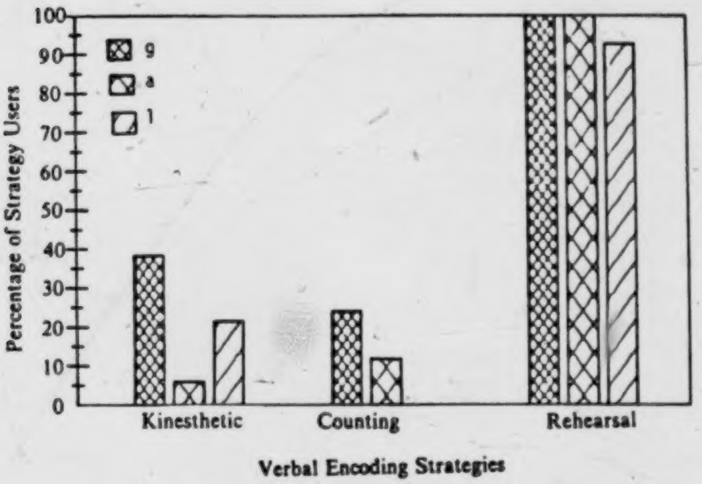


Figure 6.1
Verbal Encoding Strategy Use: Proportion of Users

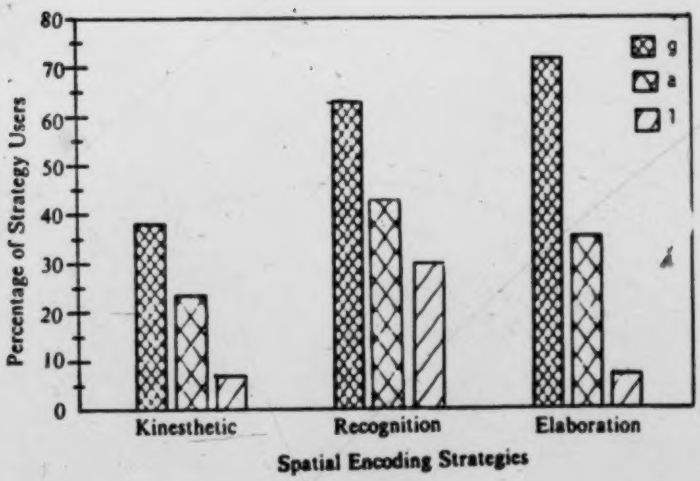


Figure 6.2
Spatial Encoding Strategy Use: Proportion of Users

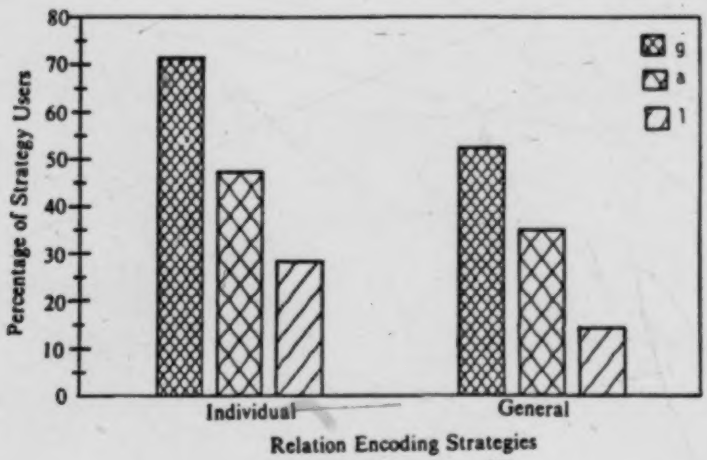


Figure 6.3
Relation Encoding Strategy Use: Proportion of Users

Table 7
Encoding Strategies: Proportion of Users

Strategies	gifted(21)	avrge(17)	L.D.(14)
Verbal			
Kinesthetic	38.1	5.9	21.4
Counting	23.8	11.8	0.0
Rehearsal	100.0	100.0	92.9
Spatial			
Kinesthetic	38.1	23.5	7.1
Recognition	61.9	41.2	28.6
Elaboration	71.4	35.3	7.1***
Relational			
Individual	71.4	47.1	28.6*
General	52.4	35.3	14.3

*** p<.001 ** p<.01 * p<.05

more often by the gifted than the learning disabled subjects ($t_{(48)}$=2.4, p<.023). Spatial elaboration was also used more often by the gifted than the average ($t_{(48)}$=3.7, p<.001) and the learning disabled subjects ($t_{(48)}$=3.33, p<.005).

The gifted subjects related the map elements to the general map frame more frequently than both the average subjects ($t_{(48)}$=2.24, p<.03) and the learning disabled subjects ($t_{(48)}$=2.84, p<.01). There were no significant group differences between the average and the learning disabled subjects in these strategies. This finding is consistent with the study by Stevens (1976). The three essential properties of spatial information processing proposed by Stevens were:

(1) hierarchical organization;
(2) inference for implicit relations; and
(3) access to proper units by searching below the highest level units.

In this model, to recognize and encode the hierarchical relationships among spatial information is very critical. The general relational encoding strategy enables learners to organize the map information in terms of hierarchical structure of spatial information. Whereas the individual relational encoding does not provide the subjects with hierarchical structure.

Most of the strategies were used more often by the gifted subjects than the learning disabled or the average subjects. Specifically, the gifted subjects used kinesthetic, counting strategies for verbal encoding, and kinesthetic, recognition, and elaboration strategies for spatial encoding. The gifted also used the strategy for encoding the general relationship.

In addition to the overall group differences independent from the cues given the group differences in strategy use for the recall trial with two different cues were examined separately by one way ANOVA. The dependent variable is the frequency of each strategy use. The one with verbal cues required the subjects to recall spatial information. The other with spatial cues required the subjects to recall verbal information. Table 10 presents the results of one way ANOVA of the group differences in the strategy use with two different cues.

When verbal recall is required, the subjects in three different groups showed significant differences in the use of the spatial elaboration strategy ($F_{(2)(48)}=4.4$, $p<.05$) and the general relational strategy ($F_{(2)(48)}=6.5$, $p<.005$). When the spatial recall is required, the three groups showed significant differences in the use of the spatial kinesthetic strategy ($F_{(2)(48)}=4.3$, $p<.05$) and the spatial elaboration ($F_{(2)(48)}=8.0$, $p=.001$). The analysis of the overall group differences showed the three groups differed in the strategy selection for the different task demands. The average and the learning disabled subjects mostly used the verbal rehearsal strategies regardless of the task demands. Whereas the gifted more often used the spatial

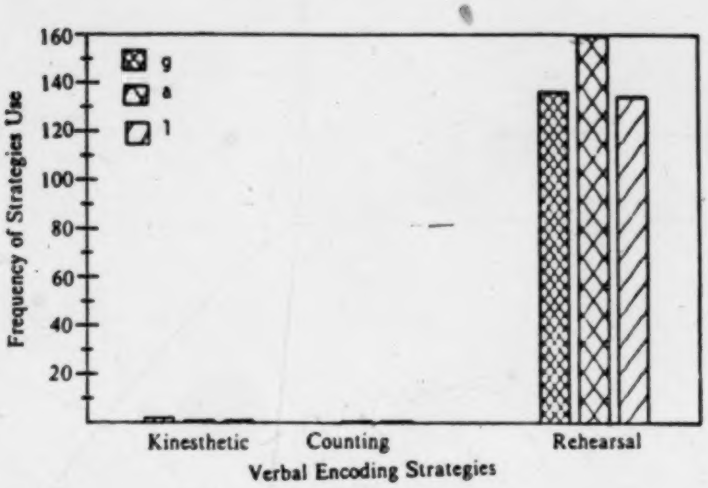


Figure 6.4
Verbal Encoding Strategies: Frequencies of Strategy Use

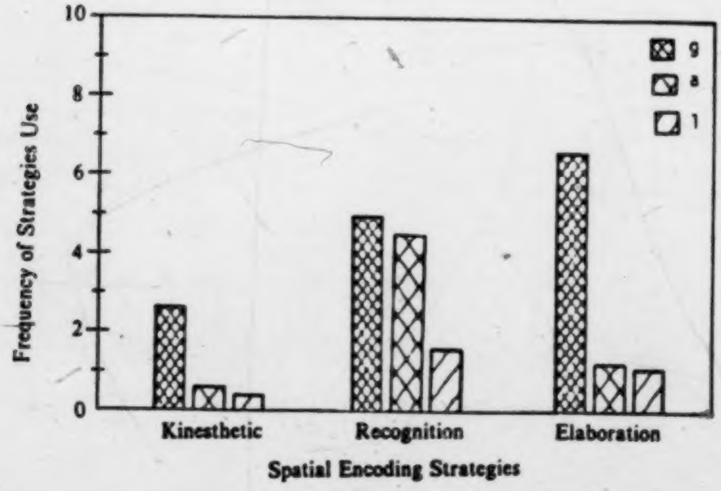


Figure 6.5
Spatial Encoding Strategies: Frequancies of Strategy Use

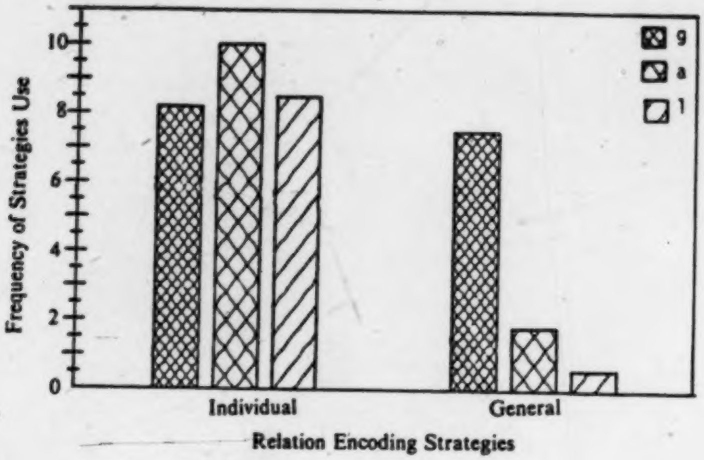


Figure 6.6
Relational Encoding Strategies:Frequencies of Strategy Use

Table 8

Encoding Strategies: Overall Frequencies

Strategies	Gifted(21) Mean (SD)	Aver(17) Mean (SD)	L.D.(14) Mean (SD)
Verbal			
Kinesthetic	1.6 (0.5)	0.6 (0.2)	0.8 (0.3)
Counting	0.7 (1.3)	0.4 (0.7)	0.0 (0.0)
Rehearsal	136.4(85.7)	159.6(102.7)	134.3(87.3)*
Spatial			
Kinesthetic	3.0 (4.4)	0.6 (1.0)	0.4 (0.6)*
Recognition	5.0 (5.4)	4.5 (7.3)	1.6 (2.8)
Elaboration	6.6 (6.3)	1.2 (2.2)	1.1 (3.4)**
Relational			
Individual	8.2 (8.9)	10.0 (19.5)	8.5(18.4)
General	7.5(11.0)	1.8 (3.3)	0.6 (1.1)*

*** p<.001 ** p<.01 * p<.05

Table 9
Group Differences in total Frequency of the Strategy Use

Strategies	G & LD	G & A	A & LD
Verbal			
Kinesthetic		*	
Counting	*		
Spatial			
Kinesthetic	*	*	
Recognition	*		
Elaboration	**	**	
Relational			
General Relation		**	*

** $p<.01$ * $p<.05$

encoding strategies when they were required to recall spatial information than verbal information. This shows groups differed in sensitivity to the change of task demands.

The differences between any two groups were further analyzed by Duncan's Multiple Range Test. When the verbal recall was required, the gifted, compared with the learning disabled subjects, significantly more often used the spatial elaboration ($t_{(48)}=2.4$, $p=.02$) and general relational strategy ($t_{(48)}=3.1$, $p=.003$). Compared with the average subjects, the gifted subjects used verbal kinesthetic ($t_{(48)}=2.3$, $p=.02$), spatial elaboration ($t_{(48)}=2.6$, $p=.01$) and general relational strategy ($t_{(48)}=2.9$, $p=.005$) significantly more often. However, there were no significant differences between the average and the learning disabled subjects in strategy use.

The differences between any two groups in strategy use were more significant when spatial recall was required than when verbal recall was required. When the spatial recall was required, the gifted subjects used spatial kinesthetic ($t_{(49)}$=2.5, p=.01) and spatial recognition ($t_{(49)}$=2.3, t<.05), spatial elaboration ($t_{(49)}$=3.3, p<.005) and general relational strategies ($t_{(49)}$=2.0, p=<.05) more often than the learning disabled subjects. Compared with the average subjects, the gifted used the spatial kinesthetic ($t_{(49)}$=2.5, p<.05), spatial elaboration ($t_{(49)}$=3.3, p<.01) and general relational strategy ($t_{(49)}$=2,0, p<.05) significantly more often. The average subjects did not show any significant differences in strategy use from the learning disabled subjects, even though the average subjects used spatial recognition and general relational strategy more often than the learning disabled subjects.

Table 10
Frequency of Strategy Use with Different Cues: Spatial Cues and Verbal Cues (Verbal Recall and Spatial Recall)

Strategies	Verbal Recall G (21)	 A (17)	 L (14)	Spatial Recall G (21)	 A (17)	 L (14)
Verbal						
Kinsthtic				0.9	0.1	0.6
Spatial						
Kinsthtic				2.1	0.5	0.4*
Recogntion				0.6	2.9	0.9
Elaborton	2.7	0.6	0.6*	4.0	0.5	0.5***
Labelng	1.3	1.4	0.4	1.8	0.6	1.1
Relational						
General Reltn	3.6	0.5	0.1**	3.9	1.4	0.6

*** p<.001 ** p<.01 * p<.05

Spatial recall requires the subjects to abstract and render the relationships among the spatial information more explicit and establish hierarchical units for better recall. Whereas verbal information does not require a great deal of transformation in this task.

One interesting point is that when the task demanded recall of verbal information, group differences were shown in spatial encoding processing strategies rather than verbal encoding strategies. When the strategy files of the subjects were closely analyzed, it was noted that more than 90% of verbal strategies used was verbal rehearsal, which was also used by the majority of the subjects in all the groups with similar frequency.

Changes in the frequency of encoding strategies over trials are presented in Appendix H. The main effects of the trials and its interaction with groups and the trials were examined by repeated measures analysis of 3 (groups) by 3 (trials) ANOVA. The frequency of each strategy use was the dependent variable. Overall, there were no significant main effects of trials in the use of most of the encoding strategies except in spatial elaboration ($F_{(2)(98)}=3.81$, $p<.05$) and verbal spatial elaboration ($F_{(2)(98)}=3.81$, $p<.05$) and verbal rehearsal ($F_{(2)(98)}=5.67$, $p<.05$). Interaction effects of the groups and the trials were shown on the use of different kinds of encoding strategies. The gifted showed an increase only in the frequency of the spatial elaboration ($F_{(2)(40)}=2.95$, $p=0.08$) even though it was not significant. The average subjects showed a significant increase in the frequency of the spatial kinesthetic strategy use ($F_{(2)(30)}=3.42$, $p<.05$). The learning disabled subjects showed a significant increase in the verbal rehearsal ($F_{(2)(28)}=5.66$, $p<.01$).

The spatial elaboration strategy used by most of the gifted was the most highly correlated with the spatial recall ($r=.53$). The spatial kinesthetic strategy also showed significant correlation coefficients with spatial recall ($r=.38$). By contrast, the verbal rehearsal strategy used by average and learning disabled subjects throughout the trials was not significantly correlated with either spatial or verbal recall.

4.2.1.3 Retrieval Strategies

The third type of process evident in the protocol was retrieval. As mentioned above, a map provides a great deal of complicated information simultaneously. Because of the demands of the task, the subjects would have benefited if they select main frames and use them as organizers. When they draw spatial elements with the help of given verbal cues, some subjects established the outline of a map by drawing main roads first and then filled the other space with names and details of spatial configuration. By contrast, some subjects retrieved individual elements.

The retrieval strategies were identified through observation and analysis of their drawing of the map. All the unlabeled spatial elements were coded by numbers according to direction. The numbers assigned to map elements increased from north to south and from west to east. The labeled spatial elements were numbered in the same way as the unlabeled elements except the labeled spatial elements were closed by parentheses. In this way, the main roads of the map were represented by consecutive numbers without parentheses and the cities and buildings by the numbers with parentheses.

While the experimenter observed the drawing of the subjects, the sequence and the type were coded by the numbers and the parentheses. One of the retrieval strategies observed was to retrieve individual cities and buildings one by one. After drawing the labeled information, some of the subjects stopped retrieving and some other subjects continued to retrieve the individual unlabeled spatial elements such as roads, railroads or border lines. Overall, more than half of the subjects drew one labeled spatial spatial element, put down the names, and then retrieved other labeled spatial elements. The other retrieval strategy was to first retrieve the main frame of the map. After drawing the main frame they continued to retrieve the individual labeled spatial elements and then put down the corresponding names of them.

The main effects of the groups were analyzed by computing Chi squares. The dependent variable was the number of subjects who used each retrieval strategy in each trial. Figure 7.1 and Table 11.1 present the group differences in the proportion of users of the retrieval strategies for the last trial. Since there was no significant difference in strategy use in the first and the second trials, only the differences in the last trial is reported.

There were not significant group differences among groups in the first and the second recall trials. Only in the last trial, were the significant group differences shown ($X^2_{(2)}$=11.9, p<.05). In the last trial, when subjects have learned the map elements more than in the first trial, 30.8% of all the subjects started drawing main frame first and then put down details and then label all the elements. Seventy five percent of these subjects were the gifted. Meanwhile, the majority of subjects of other groups repeated drawing each labeled spatial element and putting a label on it.

Group differences between pairs were analyzed by Duncan's Multiple Range Test. Across three recall trials, the gifted differed from the learning disabled subjects ($t_{(48)}$=1.9, p=.058) but the difference was not significant. There were not significant differences between the other two groups. Most of the gifted subjects retrieved the main spatial frame of a map and then the details and names of each spatial elements while average and learning disabled subjects retrieved one spatial element and the corresponding label for it.

Figure 7.2 and 7.3 and Table 11.2 present the changes in the percentage of users of each retrieval strategy over trials. To determine the differences in retrieval strategies among groups over trials, the repeated measures analysis of 3 (groups) by 3 (trials) univariate ANOVA was carried out. There were main effects of the groups ($F_{(2)(49)}$=4.32, p<.0001) and of the trials ($F_{(2)(98)}$=4.61, p<.0001). The differences in retrieval strategy use became more apparent as the study-recall trials were repeated. The source of change in group difference was identified as the strategy switching of the gifted over trials. While the majority of subjects retrieved one spatial element and its corresponding label throughout the study-recall trials, some of the gifted subjects changed from the latter strategy to retrieve the main frame first and then the details. The more the gifted experienced the task, the more they drew the main frame first.

In addition, the interaction effect between the group and the trials was also significant ($F_{(4)(98)}$=2.64, p=.000). This result shows that the groups differed not only in the kinds of retrieval strategies utilized but also differed in the switching of strategies from one to the other over learning progress after considering the efficiency of each strategy The retrieval strategy showed a significant correlation with the mean recall of map elements (r=.44). If the strategy of retrieving the main frame of the map elements is more useful in recalling the information, the

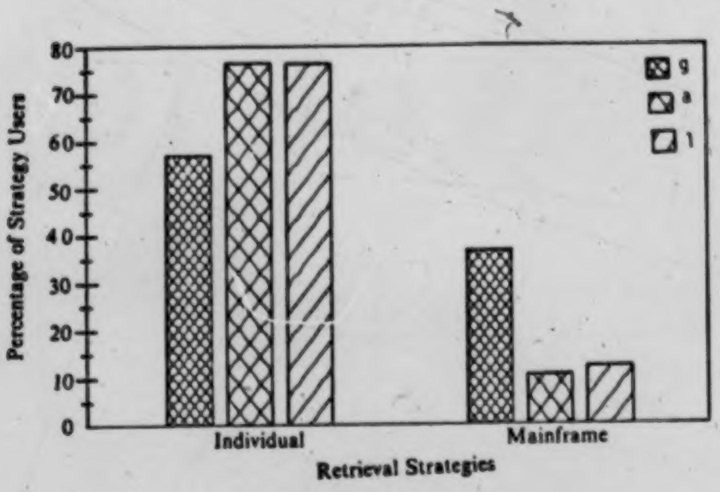


Figure 7.1
Retrieval Strategy Use for the Last Trial:
Proportion of Users of each Retrieval Strategy

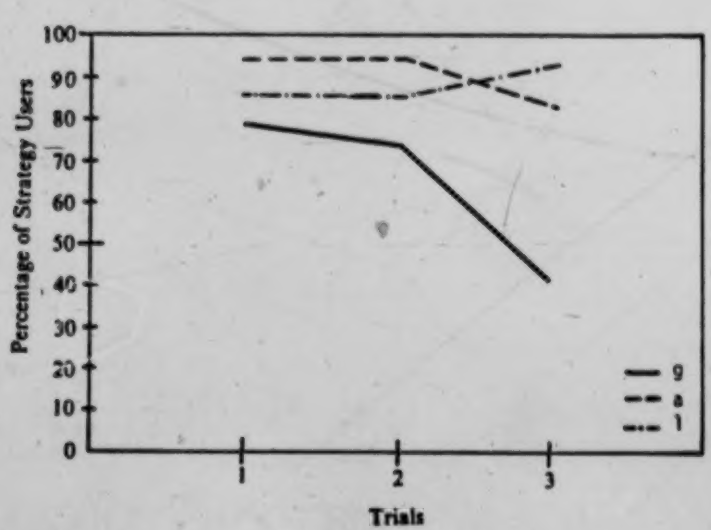


Figure 7.2
Individual Retrieval Strategy: Proportion of Users
over Trials

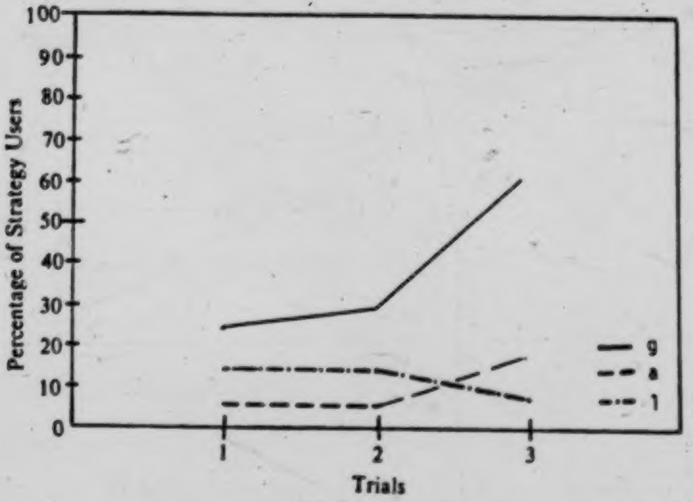


Figure 7.3
Mainframe Retrieval Strategy: Proportion of Users over Trials

Table 11.1
Percentage of Subjects: Retrieval Strategy for the Last Trial

	gifted(21)	averg(17)	LD(14)
Individual	42.9	82.4	92.9
Main Frame	57.1	17.6	7.1

Table 11.2
Proportion of Subjects: Retrieval Strategy over Trials

	trial 1	trial 2	trial 3
Individual			
gifted	76.2	71.4	42.9
average	94.1	94.1	82.4
L.D.	85.7	85.7	92.9
Main frame			
gifted	23.8	28.6	57.1
average	5.9	5.9	17.6
L.D.	14.3	14.3	7.1

efficient learner should switch their retrieval strategy to more useful one after the evaluation and monitoring.

To determine the main and the interaction effects of the retrieval strategies and the groups, 2 (retrieval strategies) by 3 (groups) two way ANOVA was carried out. The dependent variable was the total recall. Significant main effects of the retrieval strategies and the groups were shown on the total recall. Interaction effects were not significant on the total recall. The finding suggests that the fact that the gifted used the mainframe retrieval strategies more and the strategy resulted in better learning. The ANOVA results is summarized in Table 11.3.

This result is consistent with other studies which showed an organization strategy in search for retrieval cues by Wong (1982). In her study, the gifted spontaneously generated strategies for selecting the retrieval cues. They scanned the pausal/idea units and selected only those cards which had potential retrieval cues. Even though the subjects in her study did not have to generate the retrieval cues, they had to select more useful retrieval cues discarding less useful ones.

4.2.1.4. Monitoring Strategies

The subjects monitored their learning progress by considering what they had already learned and what they still needed to study. In particular, the subjects evaluated

Table 11.3
Main and interaction effects of the retrieval strategies
and the groups on total recall

Sources	MSH	MSE	F	df	P
Retrieval str	3410.0	466.6	7.30	1/46	0.009
Groups	3465.6	466.6	7.42	2/46	0.002
S X G	1306.1	466.6	2.79	2/46	0.07
RESID	466.6				

still needed to study. In particular, the subjects evaluated elements in the current focus of attention to determine whether they had learned the elements well enough to recall them later. This evaluation required a search for, retrieval of the memory representations and a comparison of the retrieved representations with the same information on the map, and a decision about whether the two were equivalent.

When the subjects decided they had not learned the information, they might then study the element using one of the encoding strategies. As can be seen in Table 5, subjects evaluated their performance more often negatively than positively.

Few subjects evaluated the task in terms of its difficulty. Monitoring was also observed in the use of the given cues. The subjects checked whether they had exhausted all the spatial elements or not by crossing out the names of the spatial element after drawing the spatial elements with labels. However, when the spatial cues were given subjects did not show the use of them to recall the names. Only three subjects checked all over the map to find out whether there were any other spatial elements that should be labeled, after they wrote down the names.

The proportion of users of each monitoring strategy across trials for each group are presented in Figure 8.1 and Table 12.1. The group differences in the proportion of subjects who used monitoring strategies at least twice throughout the study-recall trials were examined by Chi Squares analysis. There were no significant group differences in the proportion of subjects who used each of the monitoring strategy.

The frequency of positive and negative evaluation across trials are presented in Figure 8.2 and Table 12.2. The group differences in the frequency of evaluation of their learning performance were examined by one way ANOVA. There were no significant differences among the groups in terms of the frequency of each of the positive, negative, and task evaluation strategy use. Overall, the gifted subjects more often used both types of the evaluation than the other two groups of subjects.

There are very few studies which investigated group differences in the frequency of self-evaluation of learning performance. This finding is consistent with a study by Thorndyke and Stasz (1980) where the good performers used negative evaluation more than the poor performers in map learning. Nevertheless, in the study of Thorndyke and Stasz (1980), there were only 8 subjects and the significance was not tested.

In addition to the frequency of evaluation strategy use, the accuracy of the subjects' evaluations was examined. The map elements the subjects evaluated in the study trials were compared with the reproduced map in the previous recall session. The numbers of correct and incorrect evaluations were counted. The number of correct evaluation was divided by the total occurrences of the evaluation. Then, the percentages of the correct evaluation were analyzed to determine the group differences using the Duncan's Multiple Range Test. The mean percentages of the accuracy of the gifted, the average and the learning disabled group were 98.8 %, 85.8 % and 56.3 % respectively. The gifted were significantly more accurate in the evaluation of their learning performance than the learning disabled ($t_{(28)}=4.17$, $p<.0001$) but not more than the average subjects. The average subjects were also significantly more accurate in evaluating than the learning disabled subjects ($t_{(28)}=2.5$, $p<.05$). That is, good learners were superior at assessing their current state of learning and "knowing what they know".

There were group differences in using the feedback from the evaluation of the learning performance. Following evaluations, the subjects either immediately attempted to learn these elements or they moved to the next map elements without studying them. When some subjects realized that they had not yet learned an element, they immediately studied it.

To compute the conditional probability of the study attempts following the negative evaluation, the total number of negative evaluation and the number of negative evaluations followed by the study attempts were counted. The number of occurrences of the negative evaluation followed by the study attempts was divided by the total number of occurrences of the negative evaluation. The conditional probability for the gifted subjects to study an element immediately after the negative evaluation was 0.95. For the average and the learning disabled subjects, this conditional probability was 0.79 and 0.67, respectively. After making a negative evaluation, these subjects often shifted their attention to a new element without studying the unlearned information.

The results showed that the group differences were not in the frequency of evaluation. Rather the differences were in the accuracy of the evaluation and the use of the feedback from the evaluation. This result was consistent with the findings of Deshler (1974). The good readers were better in detecting errors in their performance or performance of others. In other words, they could detect the errors better than the poor readers in creative writing, spelling, editing and vocabulary. The learning disabled were inferior to their peers in detecting errors. Several studies also showed younger and poorer readers seemed to show little comprehension monitoring (Baker & Brown, 1980; Forrest & Waller, 1981; Owing, Peterson, Bransford, Morris & Stein, 1980). They know when comprehension occurred and when did not. When the good readers found that they did not understand the meaning of a passage they went back to the beginning of the sentence and reread it. The gifted subjects checked their learning progress by crossing out the given cues more frequently than the learning disabled subjects did ($t_{(48)}=2.6$, $p<.05$). The other pairs of groups were not significantly different from each other.

The changes in the frequency of the monitoring strategies use over trials were also analyzed by within subjects analysis. Overall, the subjects evaluated more frequently as they progressed over learning trials.

A repeated measures analysis of the univariate ANOVA was carried out to examine the main and interaction effects of the groups and trials. The dependent variables were the frequencies of monitoring strategies use across trials. The mean frequencies of monitoring strategy use across two maps are presented in the Figure 8.3, 8.4, 8.5 and 8.6 and Table 12.3. There were significant main effects of trials in the negative evaluation ($F_{(2)(88)}=7.65$, $p<.001$). The frequencies of the positive and the negative evaluation increased as their learning progressed. The frequency of the task evaluation decreased as the subjects progressed over trials. The interaction effect between the group and the trials were shown only in the task evaluation over trials ($F_{(4)(88)}=3.4$, $p<.05$). Only the gifted subjects used the task evaluation intensively in the beginning of the learning trials and then the use decreased significantly at their later trials

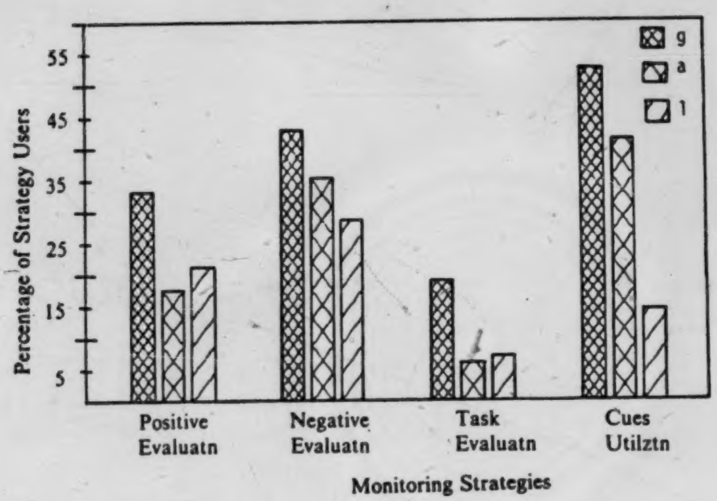


Figure 8.1
Monitoring strategies: Proportion of each strategy users

Table 12.1

Monitoring strategies: Proportion of Users

Strategies	gifted(21)	average(17)	LD(14)
Evaluation			
Positive	33.3	17.6	21.4
Negative	42.9	35.3	28.6
Task	19.0	5.9	7.1*
Accuracy	98.9	85.8	56.3**
Cues Utilization	52.4	41.2	14.3

** p<.01 * p<.05

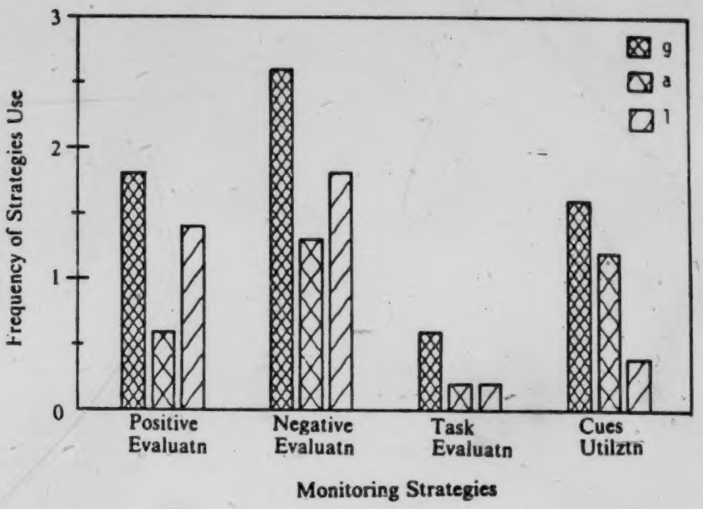


Figure 8.2
Monitoring strategies: Frequency of strategies use

Table 12.2
Monitoring strategies: Frequency of strategies use

	gifted(21) Mean (SD)	average(17) Mean (SD)	L.D.(14) Mean (SD)
Positive Evltn	1.82(4.1)	0.65(1.2)	1.35(2.6)
Negative Evltn	2.62(4.3)	1.30(1.5)	1.86(2.9)
Task Evltn	0.62(1.2)	0.21(1.0)	0.21(0.6)
Cues Utlztn	1.57(1.5)	1.17(1.5)	0.36(0.9)*

* p<.05

($F_{(2)(40)}=5.71$, $p=.006$).

The gifted subjects' study behavior was more goal directed whereas the learning disabled and the average subjects were more data driven. This was evidenced by the subsequent behaviors after the evaluation. The subsequent behaviors are mainly shown in the switching of their sampling, encoding, and retrieval strategies. As discussed in the previous sections, the gifted subjects gradually switched their sampling strategy from the systematic to the regionally focused one as they experienced the study-recall sessions. When the gifted realized that they had not learned certain map elements, they found the information on the map and focused their attention to it. The use of the strategies by the gifted showed increase in the strategies which showed high correlation with recall more as they more experience the task. The typical examples of these examples were spatial elaboration strategy, whereas the average and the learning disabled continued using the verbal rehearsal strategy which had insignificant correlation with recall. Their retrieval strategies were also changing over trials from the retrieval of the individual labeled spatial elements to the retrieval of the main frame of the map.

Meanwhile, the average and the learning disabled subjects seemed more data driven. They first focused on the map elements which happened to be in the focus of their attention. It was evidenced by a greater number of the average or the learning disabled subjects using the random sampling strategy and their subsequent study behaviors. Their study behavior was characterized by the perseverance in using one sampling strategy without switching to the regionally focused sampling strategy which is presumed to be more useful in learning the unlearned information. Furthermore, their retrieval strategies did not change over study-recall trials.

4.3 Knowledge on Map Reading Skills

The group differences were analyzed by carrying out one way ANOVA. The gifted were shown to have more knowledge of map reading skills than the average who had more knowledge than the learning disabled. The means of the scores out of 20 for the gifted, the average and the learning disabled were 11.6, 9.1, and 8.4 respectively. Standard deviations of the means for each group were 1.8, 2.7, and 3.1 respectively. Duncan's Multiple Range Test showed that there were significant group differences between the gifted and the average ($t_{(49)}=3.7$, $p=.001$) and between the gifted and the learning disabled subjects ($t_{(49)}=3.1$, $p=.004$).

It was expected that learners with good knowledge of map reading would also be the good learners since they would have been more experienced at viewing and using maps. This was significantly correlated with total recall of verbal and spatial information (r=.31) but not significantly correlated either with average recall of verbal information (r=.31)

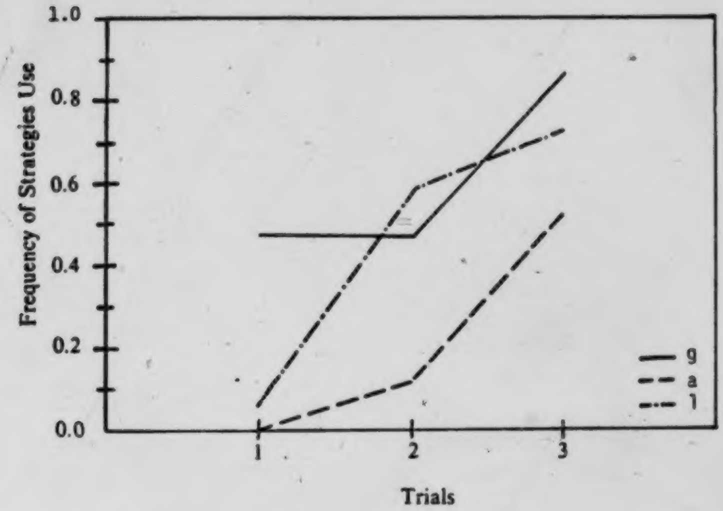


Figure 8.3
Change in the frequencies of positive evaluation strategy use over trials.

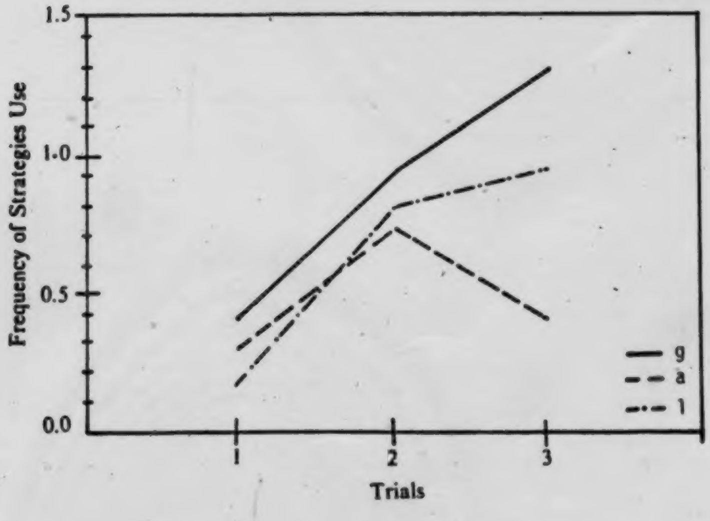


Figure 8.4
Change in the frequencies of negative evaluation strategy use over trials

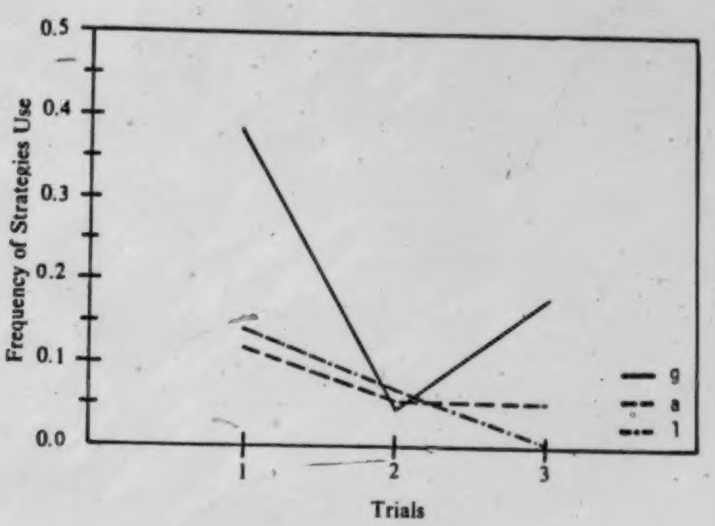


Figure 8.5
Change in the frequencies of task evaluation strategy use over trials

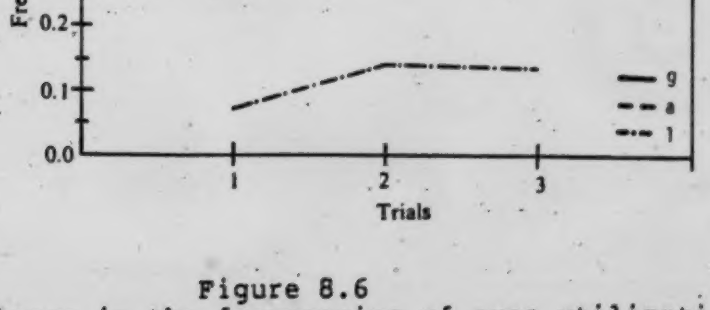


Figure 8.6
Change in the frequencies of cues utilization strategy use over trials

Table 12.3
Frequencies of Monitoring strategies use over Trials

	trial 1	trial 2	trial 3
Positive Evaluation			
gifted	0.48	0.48	0.86
average	0.00	0.12	0.53
L.D.	0.07	0.57	0.71
Negative Evaluation			
gifted	0.38	0.95	1.29
average	0.24	0.71	0.35
L.D.	0.14	0.79	0.93
Task Evaluation			
gifted	0.38	0.05	0.18*
average	0.12	0.06	0.06
L.D.	0.14	0.07	0.00
Cues Utilization			
gifted	0.57	0.52	0.48
average	0.35	0.41	0.41
L.D.	0.07	0.14	0.14

* $p<.05$

when all the data from three groups of subjects were pooled.

This result is consistent with other studies which showed the effects of experience or content knowledge on the learning performance (Chi, 1978; Chiesi, 1980). When the effects of intelligence and achievement in reading and mathematics were controlled, the knowledge in map reading skills was significantly correlated with total recall of verbal and spatial information, even though the coefficient was not so high (r=.26). It was reasoned that the low correlation coefficient of knowledge with recall was resulted from more restricted range of individual differences in the knowledge than in other studies (e.g., Chi, 1977, 1978). In Chi's (1977, 1978) studies, the differences in knowledge were as great as between the expert and novice or between adults and children. In the present study, the subjects were of the same grade and were chosen on the basis of IQ and achievement rather than the knowledge on map reading skills. This could result in the regression to the mean of the content knowledge.

4.4. Sources of Individual Differences

Although consistent differences in cognitive and metacognitive strategies, and knowledge base were demonstrated, it is not clear which one of these several potential sources of individual differences plays the most important role in determining individual differences in learning spatial and verbal information. As reviewed in Chapter 2, learning can be improved through the use of such learning strategies as organization (Divesta, Schultz, & Dargel, 1973; Frase, 1973), elaboration (Canelos, 1983; Rasco, Tennyson, & Boutwell, 1975), or chunking (Belmont & Butterfield, 1971; Hunt & Love, 1972; Estes, 1974). Other studies have demonstrated that individual differences might result from differences in knowledge base in specific content area (Chase, 1978; Chi, 1978; Voss, 1978). Other researchers suggest that monitoring, which is executive metacognition, represents an important source of systematic individual differences in learning and memory tasks.(e.g., Flavell,1978; Kreutzer, Leonard, & Flavell, 1975; Lodico, et. al., 1983). To investigate the source of the individual differences further, the intercorrelation, the partial correlation, and the stepwise multiple regression analyses were carried out.

4.4.1. Correlations

Intercorrelations between subjects' strategy profile and learning performance were computed to ascertain the characteristics of a learner's behavior. The resulting correlation matrix is shown in Appendix H. With the exception of a few low correlations that have been included for the purpose of further discussion, only significant correlations are shown.

Three measures of learning were used: Mean percentage of spatial elements correctly recalled per trial (variable 1); Mean percentage of verbal elements correctly recalled per trial (variable 2); and mean score of navigation problem solving (variable 3). Variable 4 is the score of knowledge on topographic map reading skills. Six measures of their ability and achievement scores were included to provide information on the relationship between the ability, knowledge in map reading skills, and strategy use. They are verbal intelligence (v5), quantitative intelligence (v6), nonverbal intelligence (v7), mathematics achievement (v8), reading decoding (v9), and reading comprehension (v10).

Variables 11 through 14 corresponded to the sampling strategies subjects used in the 2nd trial of the first map, in the 3rd trial of the first map, 2nd trial of the second map, 3rd trial of the second map respectively. Variables 15 through 28 corresponded to the strategies observed during their study recall trials, and with few exceptions, were used by more than three subjects.

All the intelligence scores are highly correlated with the recall of spatial and verbal information. The correlation coefficient between the mean recall of spatial information and the verbal intelligence was .35. The spatial recall was more highly correlated with the quantitative (r=.39) and with the nonverbal intelligence (r=.40). In the recall of verbal information, the correlation coefficients with the verbal intelligence, quantitative intelligence, and the nonverbal intelligence were .36, .39, and .26 respectively. Mathematics achievement scores were significantly correlated with the recall of spatial information (r=.36) and with the recall of verbal information (r=.37). The reading decoding and reading comprehension were significantly correlated with the recall of verbal information (r=.37 and r=.35 respectively) but not with the recall of spatial information.

Of the learning strategies, spatial kinesthetic (r=.38), spatial elaboration (r=.53), and retrieval strategy (r=.44) were highly correlated with the spatial information recall. Only the utilization of cues was highly correlated (r=.37) with the recall of verbal information. Knowledge base on map reading skill was also significantly correlated with the mean recall of map elements (r=.31) but not with either spatial recall or with verbal recall.

4.4.2. Partial Correlations

Since the ability scores were highly correlated with map learning performance, it was necessary to control the effects of the ability variables and achievement variables to see the uconfounded effects of encoding strategies, knowledge and monitoring. Because the number of levels of controlled variables is limited to 5, nonverbal IQ which had the lowest correlation with the mean recall of spatial and verbal information was omitted from the set of controlled variables. The resulting summary of the correlation matrix is shown in Table 13 when all of the verbal IQ, quantitative IQ, reading decoding, reading comprehension, and mathematics were controlled. The partial correlation coefficients were computed between the recall performance (mean recall, spatial recall, verbal recall) and knowledge in map reading, sampling, verbal and spatial encoding strategies, retrieval strategies, and monitoring strategies. Such spatial encoding strategies as kinesthetic, labeling, and elaboration were significantly related. Retrieval strategies were also significantly correlated with spatial recall. With verbal recall, relation encoding strategies (specifically relating individual elements each other) and monitoring (utilizing the given cues) were significantly correlated. Overall, the spatial elaboration was the most significantly related with the recall of map elements (r=.42, p=.002). Retrieval strategy (r=.27, p=.007) was also significantly correlated with the recall of map elements.

Knolwedge on map reading skills were correlated with spatial recall (r=.23, p=.063) and with verbal recall (r=.24, p=.054), but they were not significant. With mean correct recall of spatial and verbal elements, spatial kinesthetic, spatial elaborating, individual relational encoding strategies were significantly correlated. In

Table 13
Partial Correlation : controlled for IQV, IQQ, math, reading decoding, and reading comprehension

Variables	Mean Recall	Spatial Rc	Verbal RC
1.KNWLG	.26 *	.23	.24
2.SMP2	.13 *	.08	.33*
3.SMP4	.20	.17	.21
4.VKIN	.15	.13	.13
5.VCNT	.03	.02	.09
6.VRHS	-.004	-.03	.12
7.SKIN	.33 *	.32 *	.12
8.SREC	-.13	-.13	-.01
9.SLAB	.30	.31 *	.03
10.SEL	.42 *	.44 ***	-.03
11.RIN			.26 *
12.RGEN			.20
13.EPO	.20		
14.ENE			
15.ETA	.23	.24	
16.RTRV	.27 *	.37 **	
17.CUS	.26 *		.30 *

*** p<.001 ** p<.01 * p<.05

addition, retrieval strategy, utilization of knowledge on knowledge on map reading skills were also significantly correlated.

4.4.3. Stepwise Multiple Regression Analysis

To understand the main source of the systematic individual differences in acquiring verbal or spatial information, stepwise multiple regression analysis was implemented. The stepwise procedure was used because the subset of strategies that would be predictive of performance probably could not be identified a priori. Table 14.1, 14.2, and 14.3 show the order in which variables entered the regression analysis and their contributions to subject variance in total correct recall, spatial recall and verbal recall of map elements respectively.

Five variables -- spatial elaboration, spatial kinesthetic, spatial labeling, retrieval strategies and knowledge in map reading skills -- were used for the analysis. The variance of performance accounted by all the five variables was R^2=.463. Out of the five variables only three variables were found to significantly account for the performance variance of the subjects. The variable which explains the group differences in mean recall the most was the spatial elaboration strategy (R^2=.266). The next two variables were retrieval strategy and the knowledge in map reading skills. These four variables, then, constitute the set of independent predictors of subject performance on learning information from maps.

Of the remaining variables that were significantly corrrelated with the average recall of map elements, spatial kinesthetic and spatial labeling strategies were correlated with spatial elaboration and thus did not have significant regression weights. These intercorrelations, if not spurious, might have been obtained for one of two reasons: gifted subjects might have used one or more macro-strategies, that is, strategies incorporating several of the observed information processing strategies, or the strategies might have been independent, but good learners might have known and used all of them.

Table 14.2 and 14.3 shows the variables that are predictive of recall of spatial and verbal information. As can be seen in the Tables, four variables were used to predict the performance variance of the subjects in the recall of spatial information. The variance accounted for by the set of the four variables was $R^2=.473$. However, out of the four variables, only the spatial elaboration and the retrieval strategies signinificantly contributing to the performance of spatial recall.

For verbal recall, sampling strategies in the last trial of each map, utilization of the given cues, and the knowledge of map reading skills were used. The variance explained by the four variables was $R^2=.331$. Out of the four variables, only the sampling strategy ($R^2=.159$) and cues

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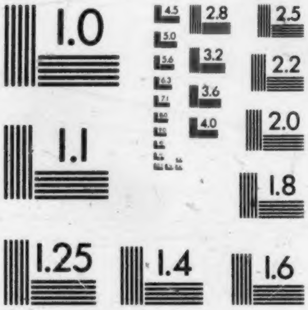
1.0
4.5
2.8
2.5
5.0
3.2
2.2
5.6
6.3
3.6
7.1
8.0
4.0
2.0
1.1
1.8
1.25
1.4
1.6

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utilization strategies (R^2=.089) significantly contributed to the subjects' verbal recall. This regression analysis shows that specific encoding strategies accounted for more variance of learning performance of the subjects than the knowledge in the map reading skills or monitoring strategies.

There have been very few studies which investigated the relative contribution of these variables to learning performance. In this study, the specific cognitive strategies in encoding and sampling accounted for more of the variance in recall than the knowledge in map reading skills. This would suggest that how new knowledge is acquired is important or more so than how much knowledge a person previously acquired in explaining individual differences in cognitive ability.

This finding is not totally consistent with other studies which showed the knowledge base as a major determinant of individual differences. Chi (1977, 1978) suggested that the differences in memory span and cognitive performance are resulted from the differences in the familiarity with the tasks rather than working memory capacity. In these studies, only the familiarity with tasks was controlled. It was assumed that the unfamiliarity with the task prevents the subjects from using strategies. However, this assumption was not carefully examined, and there could be a confounding effect of knowledge and strategies on the recall of subjects.

In the present study, the gifted who had significantly more knowledge on map reading skills used strategies which are highly correlated with the recall. The use of these strategies increased as the gifted more experience the task. Contrarily, the average and the learning disabled did not use these strategies as often as the gifted and the use of these strategies did not increase over the trials. The change over trials in the use of the strategies suggest that the strategy use is closely related to the knowledge acquired. At present, it is not possible to compare the results with other studies in terms of the relative importance of knowledge base and strategies, since it has not been systematically studied (e.g., Chiesi, Spilich, & Voss, 1979; Spilich, Vesonder, Chiesi, & Voss, 1979).

The specific cognitive strategies accounted for more variance of recall performance than monitoring strategies. It may also suggest that what kind of specific strategies an individual uses for sampling, encoding, and retrieval may be a more important reason for the individual to show different performance than whether they monitor how well they are learning. Or it may imply that the monitoring strategies affect learning but if the individual is not equipped with specific strategies for each stage of information processing, the monitoring does not bring about better learning, although, the overall variance accounted for by the set of variables was not more than 0.50. This suggests that there are other reasons for individuals distinguishing different performance.

Table 14.1
Variables introduced in Stepwise multiple regression of mean correct recall of map elements

Variables	R	R^2	R^2 incrmnt
1.Sptl Elbrtin	.52	.266	.266
2.Retrieval	.61	.375	.109
3.Knldg: Map Readn	.67	.443	.078
	-	-	-
	-	-	-
4.Spatial Kinsthetc	-	-	-
5.Sptl Labelng	.68	.463	.020

R: multiple correlation coefficient
R^2: Proportion of variance accounted

Table 14.2
Variables introduced in Stepwise Multiple Regression of Spatial Recall Performance

Variables	R	R^2	R^2 Increment
1.Spatial Elaboration	.53	.277	.277
2.Retrieval	.62	.384	.107
	-	-	-
	-	-	-
3.Spatial Kinesthetic	-	-	-
4.Spatial Labeling	.68	.473	.089

Table 14.3
Variables Introduced in Stepwise Multiple Regression of Verbal Recall Performance

Variables	R	R^2	R^2 increment
1.Sampling 2	.40	.159	.159
2.Cues Utilization	.50	.248	.089
	-	-	-
	-	-	-
3.knolwedge:map reading	-	-	-
4.Sampling 4	.58	.331	.083

R: Multiple correlation coefficients
R^2: Proportion of variance accounted

5. CONCLUSIONS AND IMPLICATIONS

The conclusions should be of interest to educators concerned with teaching specific or metacognitive strategies to students of different cognitive ability in order to optimize the learning and retention of information. One caution is that the study involved grade 4 students from the Edmonton Public School District who may have been in the process of developing the proficiency with several strategies. For students who are more or less mature users of these strategies, the findings on recall, strategies use, and the result of regression analysis might be quite different. Therefore, the findings are limited to grade 4 students. Replications of the study at other grade level are required before the results can be justifiably applied to students in other age group.

5.1 Individual Differences in Learning

The gifted recalled significantly more information than the average and the learning disabled. There were no significant differences between the average and the learning disabled subjects in both verbal and spatial recall. There were interaction effects of the groups with the trials in recall of verbal information. The gifted showed contrasting trends in the increase of verbal recall and unlabeled spatial information recall over trials. Whereas the average and the learning disabled showed minimal differences between the increase of verbal recall and unlabeled spatial information. This finding suggests that the gifted is more sensitive to the change of task demands and they spent more time in analyzing and encoding the hidden structure of unlabeled spatial information into more explicit form. The elaborate encoding presumably facilitated subsequent operations on these encoded information.

On the navigation problem solving, the gifted were significantly better than the average and the learning disabled subjects. The task requires subjects to integrate the survey knowledge acquired throughout the study-recall trials with the procedural knowledge acquired while they view the circle movements. Using the knowledge of a map on the object locations and inter-object distances with respect to a fixed global coordinate system, the subjects are required to recall the points along the route where turns occur and the directions taken at once.

It was observed that there are several differences in strategy usage between the gifted, the average, and the learning disabled subjects. The gifted subjects spent more time in understanding the problem in the beginning of their learning as evidenced by the change in the frequency of task evaluation and slow increase in unlabeled spatial recall over trials. The gifted also structured the learning task by deciding how to segment and focus systematically on subsets of information from the map. They demonstrated a variety of successful strategies for learning spatial configurations and verbal labels. They retrieved the information that they studied by establishing a general framework of the entire map before they started writing the individual map elements. They utilized given cues fully, so that they could self-check their recall performance. Finally, they evaluated their learning progress consistently and accurately using their knowledge about their own uncertainties to determine their attentional focus for sampling information and their subsequent study behaviors. This was evidenced by their change from systematic sampling strategy to a regionally focused sampling strategy and their conditional probability of studying the unlearned information.

Information processing strategies of the average and the learning disabled subjects deviated in a number of ways from that of the gifted subjects. These deviations might be regarded as obstacles in their learning procedures that interfered with their learning progress. The present study identified nine obstacles in their use of information processing strategies. Each of the average and the learning disabled subjects exhibited some of them but not all ofthem. These difficulties are summarized briefly below. They are grouped according to type of information processing: 1 is difficulty in sampling process, 2 through 4 are difficulties in encoding processes, 5 is in retrieval and 6 through 9 are in metacognitive strateiges.

1. No attention-focusing plan. The subjects made no decision about how to segment and sample information from the map. Their attentional focus appeared to shift randomly around the map. At the best, they would shift their attentional focus to adjacent elements in one direction without a certain purpose or plan.

2. Ineffective strategies. The strategies employed to learn information did not produce much learning. For example, the main encoding strategies that the learning disabled used were verbal rehearsal and spatial recognition. The verbal rehearsal and spatial recognition strategies showed a negative correlation coefficients with the mean recall as well as the recall of spatial information. Even with the recall of the verbal information, the verbal rehearsal strategy showed a very low correlation.

3. Unavailability of strategies. The number of different kinds of strategies were less than the ones of the gifted subjects. As a result, the subject often could not think of strategies for learning certain information on the map. Typically this meant the subject was unable to usestrategies on complex spatial information. For example, he or she would decide to learn all the street locations but could not think of strategies for doing so.

4. Failure to integrate knowledge. The subjects could not integrate different types of knowledge that they

acquired during their study. Even when they recalled individual elements correctly, they often would fail in putting these elements together. For example, names of buildings and cities were learned, but the subjects would fail to integrate the information, resulting in errors in placement of the names with the corresponding spatial configuration.

5. No generation of cues. Subjects could not use the general frame of the map as a cue to recall and integrate the rest of details. For example, they started to retrieve the individual labeled spatial elements separately. In this way, the information on the organization of the map elements could easily be lost from the memory while they were writing down individual items.

6. Non-use of given cues. Subjects failed in using the given cues to check whether they exhausted all the possible answers for the problem. For example, when they were asked to recall the spatial elements given the names of the cities or buildings as cues, they did not cross out the names to check whether they wrote down at least all the labeled spatial elements.

7. Inaccurate evaluation. The subject inaccurately decided whether or not he or she had already learned an element. For example, they often stated that they remembered certain map elements even though the mentioned elements were not correctly recalled in the previous study-recall trial.

8. Premature abandonment. The subject abandoned the

plan for structuring or the use of a useful strategy prior to its completion. It was evidenced by the frequent use of random sampling. They used the presumably useful strategies once or few times and would start using other strategies even before they completely learned the unlearned map elements.

9. Failure to use evaluation feedback. After deciding that an element had not been learned, the subject would shift his or her focus of attention to a new element without studying the unlearned information. In addition, they did not switch their strategies according to their learning progress. Meanwhile the gifted switched the strategies more flexibly. It was evidenced by constant use of verbal rehearsal strategy and persistent retrieval of individual elements without changing to main frame retrieval strategies.

5.2 Relationships among Strategies, Knowledge base and Recall Performance

It is evident from these analyses that successful map learning depends to a significant degree on the particular information processing strategies that are useful for this task. As noted earlier, an important characteristic of the map learning task is that all the information to be learned is presented simultaneously. As a result, rate and content of information availability depend on the decisions and actions of the learner. The lack of structure in the learning procedure increases the importance of employing appropriate strategies for learning. In fact, the influence of strategies on determining learning rate outweighs the potential effects of prior experience with using or learning maps. It was evidenced by more recall performance variance accounted for by the specific cognitive strategies than the one accounted for by the knowledge in map reading skills. Sternberg (1984) also pointed out that the way that the knowledge is acquired is more important than the knowledge or experience itself.

While the data identify important individual differences in recall and strategies use, it can only be speculated as to the cause of these differences. Hunt (1978) discussed three sources of individual difference in cognition -- knowledge, the mechanics of information processing and simple processing strategies. Flavell and Brown (1978) suggest metacognition as another important source of individual differences. The data obtained in thisstudy using the test on topographical map reading skills suggests that the knowledge of the problem contributes to the subjects' differences in learning performance.

In addition, mechanics of information processing, simple information processing strategies and monitoring are plausible predictors of map learning performance. The elementary mechanics of information processing including decoding is highly correlated with verbal ability and is suggested as stable individual traits (Hunt, 1978). This process is an important component of knowledge acquisition regardless of the high-level strategies subjects use during study .

This study focused primarily on high-level processes involving strategies and knowledge. This result provides indirect support for the hypothesis that high-level processes are important in explaining performance differences.

The most significant predictors of performance, however, appear to be the specific cognitive strategies that subjects invoke during learning. Even on simple processing tasks subjects vary in the type of processes they use (Hunt, 1978), and in their effectiveness in using common strategies (Sternberg, 1978, 1981). In this study, subjects varied markedly in the strategies they used and the strategy profile did predict the degree of success on the task. It was shown in the group differences in the frequency of strategy use, especially in spatial elaboration, retrieval strategy, and cues utilization, task evaluation strategies. The variance of recall performance accounted for by the specific strategies was greater than the one by the knowledge in map reading skills or the metacognitive strategies.

However, the relative contriubtion of the individual differences in learning would also be determined by thenature of the task to be learned. For example, if the task is relatively new, so that most of the subjects do not have much differences in terms of their knowledge in the specific content area, the strategy to utilize knowledge in other areas and to find meaningful contexts between the incoming material and stored knwoledge would play a more important role than the knowledge base. In other words, how knowledge in other areas is utilized to find any relationship between the stored knowledge and the incoming information is more important than other components in explaining the individual differences in learning. In contrast, if the task is quite familiar to most of the subjects, the individual differences in learning may be accounted for more by monitoring strategies than knowledge base or specific strategies. If the degree of familiarity of a task to be learned is quite different among subjects, the individual differences in learning may be accounted for more by the knowledge base than specific strategies or monitoring. It is evidenced, in this study, by the fact that variance in learning different kinds of information was accounted for by different sets of predictors. For verbal learning, metacognitive strategies were a set of predictors, whereas spatial learning was accounted for by specific strategies. It was reasoned that children were quite familiar with verbal information, but not familiar with spatial configuration. In addition, the degrees of familiarity of the task among subjects was quite similar to each other's.

5.3 Educational Implications

It has been well recognized that we live in an age of fast discovery and accumulation of new knowledge. The amount of information that can be put into the school curriculum far exceeds the student's ability to assimilate and retain it. It is also recognized that the main role of the teachers is to help children prepare for an information age by adopting the systems of education and theories of learning and instruction. The students should be provided with a tool with which they can get the most not only from their schooling experience but also from their working place even after their graduation. Especially those who work in science-based area should abreast with new information. Without a tool which helps individual to extract and organize information in an economical way.

In this study, some of the specific cognitive strategies, monitoring and knowledge base were found to be significantly related to learning of the children. Unlike other studies suggesting the knowledge base is a major determinant of individual differences, the cognitive strategies were found to account for more performance variance than the content knowledge at least when the task is not so familiar to the students. From this finding, it can be hoped that even a student who does not have as much knowledge as others can perform better if the student can employ effective strategies as efficiently as the gifted.

This likely would be more true when the individuals are young and when the differences in content knowledge among individuals are not as great as among adult individuals.

There have been several applied studies focusing on strategies developing either classroom applications or adjunct programs that can help students become more proficient in learning strategies. For example, Jones & her colleagues (Jones, Amiran & Katims, 1983) have concentrated on embedding learning strategies instruction into regular reading curriculum materials. Dansereau (1983) and Weinstein and Underwood (1985) have all focused on creating adjunct, or independent programs to help college students in either job or college settings. Some of this work has included examining the role of spatial learning techniques both as an instructional vehicle and as a component in the other types of strategies taught.

The focus on high school and college students in the area of learning strategy programs is perhaps an indication that those students more frequently deal with tasks which require the use of strategies and that it is easier to implement the programs to the older students than to younger students. However, the findings of this study and other studies imply that the learning performance of even fourth grade students are differentiated by their learning strategies and that interventions may have more potential value if they are instituted as early in the child's life as possible.

Training on strategies can be implemented either in an embedded setting or in a special program. When it is taught with other subject materials, the students should be aware of the usefulness of each strategy. The importance and usefulness of each strategy can be explicitly pointed out to students. When it is taught in a special program, they should be aware of the fact that the strategies can be used to solve the problems they face everyday or in other subjects areas. In addition, before any training on strategies is implemented, the assessment of availability of the specific strategies or the knowledge at the initial stage of training should be carried out for successful training.

The interaction effects between the trials and the groups on recall and strategies use suggest the importance of monitoring strategies. Even though the monitoring strategies did not account for as much of the performance variance as the specific strategies, the switching of strategies from less effective strategies to more effective ones and the increase in the frequency of effective strategies use over trials was one of the significant differences among groups. The improvement in learning would be facilitated if the teaching of specific cognitive strategies are companied by the one of metacogitive strategies.

It was clearly found that a deployment of strategy does not guarantee a better learning unless the strategy is used appropriately for a given task with efficiency. For example, a verbal rehearsal would be useful for remembering a phone number. The verbal rehearsal, however, may not be appropriate for learning the relationship between the roads and landmarks in a map.

The interaction effects between the groups and different kinds of strategies on learning should also be considered in selecting strategies to be taught. Even though the interaction effects were not the main focus of the study, the findings on the use of retrieval strategies in terms of its interaction with the groups suggest that the best strategy for the gifted may not always be the best one even for the children in other groups. In addition, it is not examined whether the strategies used by the gifted and found to be more effective can also be beneficial when used either by the average or the learning disabled subjects after being trained.

5.4 Suggestions for further study

This study identified individual differences in recall, cognitive strategies, metacognitive strategies, and knowledge base and their interrelationships. As a result of this study, the following suggestions could help in further studies of learning strategies and cognitive ability.

1. It would be desirable to consider the automaticity of information processing for effective training of the

strategies. On the one hand, it might be presumed that the average and the learning disabled subjects could be trained to use the high level processing strategies that were observed in the gifted subjects and were correlated with performance. Because these strategies accounted for much of the variance in learning, it might be expected that learners who could be taught to use them could significantly improve their learning performance. On the other hand, it would be desirable to consider the automaticity of information processing. As suggested by Dempster (1981), if low-level, automatic information processes account for much of the variation in learning performance, or if the use of high-level strategies depends upon these automatic information processes, then it might be expected that a subject's performance to be constant across various training conditions. If this hypothesis were correct, for example, the average and the learning disabled subjects might not be able to learn to use higher-level information processing strategies because all the space in working memory will be occupied by the basic information processing. Similarly, self-monitoring of their study behaviors and learning progress will be so dependent upon the immutable automatic processes that strategy training would prove largely unsuccessful in altering performance. While both hypotheses have received empirical support in various other task domains, this issue remains an open question in the current task domain which requires both of verbal and spatial information processing.

2. It would also be necessary to investigate the metacognitive processes in terms of strategy selection and strategy switching. The present study partially investigated it by analyzing the trial effects on recall and strategy use. The group data from the present study showed that gifted subjects' use of spatial elaboration strategy significantly increased over trials, while the other groups did not show significant increase. However, from this data, it is not known how an individual switched their encoding strategy from one to the other in sequence. The application of the case study approach and the ethnographic methodologies would potentially enhance the understanding of the effects of metacognitive strategies.

3. Interaction effects between different kinds of strategies and the groups on learning should be studied to identify the optimal strategy for children of different cognitive abilities. In this study, only the sampling and retrieval strategies were included for the investigation of interaction effects on learning. Very few strategies are equally effective for all the students. It would be surprising if the spatial elaboration strategy were a panacea for all kinds of learning of all the students. Some individuals of the different cognitive abilities may perform differently using the same strategy.

4. The interaction effects between the aptitude and the use of strategy should be studied. Individuals who have

high verbal aptitude and those who have high visual aptitude would benefit differently from using a certain kind of strategy. The training effects would also be different for individuals of different aptitude.

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Appendix A

Academic Challenge Program Identification Matrix and Behavioral Rating Scale

ACP 1985

ACADEMIC CHALLENGE PROGRAM IDENTIFICATION MATRIX

NAME: ______________________ I.D.: ____________

SCHOOL: ______________________ GRADE: _____ DATE: ____________

Indicate the student's most recent scores on ability (I.Q. or Standard Age Score), achievement (percentile scores for age/grade), and teacher rating (raw score) in the appropriate box. For each area, circle the weighting factor which corresponds the student's score. Total the weighted scores. Submit this matrix, a completed ACP Rating score and Academic Challenge Program Application Form to the Student Placement Office.

TYPE OF TEST	DATE OF TEST	ABILITY ASSESSMENT	IQ or SAS	145+	137 - 144	130 - 136	122 - 129	121 and below
A. Multi-Component Intelligence Test		CCAT Verbal Level ____		4	3	2	1	0
		WISC-R Verbal						
		CCAT Quantitative Level ____		4	3	2	1	0
		WISC-R Non Verbal						
		CCAT Non Verbal Level ____		4	3	2	1	0
		WISC-R						
B. Single Score Intelligence Test		CCAT Primary Level 2 ____		12	9	6	3	0
		Stanford Binet						

12

DATE OF TEST	ACHIEVEMENT ASSESSMENT	Percentile	99%ile	95 - 98%ile	90 - 94%ile	85-89%ile	84%ile & below
	CTBS Mathematics Concepts Level ____		4	3	2	1	0
	CTBS Reading Level ____		4	3	2	1	0
	CTBS Visual Materials Level ____		4	3	2	1	0
	CTBS Listening Level 6 (only)						

12

TEACHER RATING	Raw Score	50-60	40-49	35-39	30-34	25-29	15-24	14 & below
ACP Rating Scale		6	5	4	3	2	1	0

6

TOTAL WEIGHTED SCORE (Ability + Achievement + Rating) = 30

COMMENTS (Include other evidence or indications of gifted performance or potential, the student's need for differentiated programming, etc. Use back of form.)

ACP 1985

ACADEMIC CHALLENGE PROGRAM RATING SCALE

STUDENT ______________________________ GRADE __________

SCHOOL ______________________________ RATER __________

DIRECTIONS: CHECK THE APPROPRIATE BOX BESIDE EACH ITEM WHICH BEST DESCRIBES THE STUDENT'S BEHAVIOR IN COMPARISON WITH OTHER STUDENTS HIS/HER AGE. ADD THE CHECKS IN EACH COLUMN, THEN MULTIPLY THE NUMBER OF CHECKS BY THE WEIGHTINGS INDICATED. ADD THE WEIGHTED SCORES FROM EACH COLUMN TO OBTAIN THE TOTAL SCORE.

OUTSTANDING (TOP 5%)	EXCELLENT (TOP 10%)	ABOVE AVERAGE (TOP 25%)	AVERAGE/OCCASIONALLY	BELOW AVERAGE/LIMITED	
☐	☐	☐	☐	☐	1. IS CURIOUS. INQUIRES ABOUT MANY VARIED TOPICS. EXPLORES NEW THINGS AND IDEAS.
☐	☐	☐	☐	☐	2. GENERATES MANY IDEAS OR RESPONSES TO A QUESTION OR TASK.
☐	☐	☐	☐	☐	3. GENERATES AND CONSIDERS ALTERNATIVE SOLUTIONS AND POINTS OF VIEW.
☐	☐	☐	☐	☐	4. DEVISES NEW METHODS OF PROBLEM SOLUTION, OR PRODUCES UNIQUE AND IMAGINATIVE RESPONSES OR PRODUCTS.
☐	☐	☐	☐	☐	5. IS A KEEN AND ALERT OBSERVER. USUALLY SEES MORE OR GETS MORE OUT OF A STORY, PICTURE, EXPERIENCE, ETC., THAN OTHERS.
☐	☐	☐	☐	☐	6. ELABORATES THROUGH DETAIL AND COMPLEXITY WRITTEN AND ORAL RESPONSES, DRAWINGS, MODELS, ETC.
☐	☐	☐	☐	☐	7. IS HIGHLY SELF-MOTIVATED. BECOMES ABSORBED IN A TOPIC, CARRIES INTEREST TO INDEPENDENT AFTER-SCHOOL ACTIVITIES.
☐	☐	☐	☐	☐	8. WORKS INDEPENDENTLY. DISPLAYS INITIATIVE AND REQUIRES LITTLE DIRECTION TO CARRY THROUGH ON TASKS.
☐	☐	☐	☐	☐	9. SETS REALISTIC GOALS. ORGANIZES TIME AND TAKES INTO ACCOUNT THE ELEMENTS OR DETAILS NECESSARY TO ACCOMPLISH THE TASK.
☐	☐	☐	☐	☐	10. FORESEES CONSEQUENCES OR EFFECTS OF ACTIONS OR DECISIONS.
☐	☐	☐	☐	☐	11. IS PERSISTENT IN TASK COMPLETION INCLUDING TASKS WHICH ARE ASSIGNED BUT WHICH MAY HOLD LITTLE INTEREST.
☐	☐	☐	☐	☐	12. HAS A READY GRASP OF UNDERLYING PRINCIPLES AND CAN QUICKLY MAKE VALID ASSOCIATIONS AND GENERALIZATIONS ABOUT EVENTS, PEOPLE OR THINGS.
☐	☐	☐	☐	☐	13. SETS HIGH STANDARDS FOR OWN PERFORMANCE OR PRODUCTS.
☐	☐	☐	☐	☐	14. UNDERSTANDS COMPLICATED MATERIALS OR IDEAS. REASONS THINGS OUT LOGICALLY.
☐	☐	☐	☐	☐	15. IS A HIGH RISK TAKER. EXPLORES OR DEFENDS UNUSUAL IDEAS.
☐	☐	☐	☐	☐	TOTAL
X4	X3	X2	X1	X0	MULTIPLY BY WEIGHTINGS
☐	☐	☐	☐	☐	WEIGHTED SCORES

TOTAL OF WEIGHTED SCORES ☐ /60

Appendix B: Topographical Map Reading Skills

Topographic Map Reading Skills Test

Reference Map

Topographic Map Reading Skill

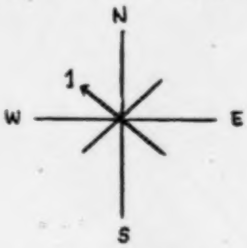
Name____________________________

School____________________________

Date____________________________

The following questions are about what the map symbols represent, and what we can know from the map. Please read the questions carefully and circle the number that you think a correct answer. To answer some questions, you may need to consult the map attached to it.

1. What direction is the arrow marked 1 pointing out?
   - a. northwest
   - b. southeast
   - c. south
   - d. north



2. Find Lake Wales. If you went directly toward the bottom of the map from it, you would be going:
   - a. east
   - b. south
   - c. west
   - d. north

3. Find the railway that runs in the directions of southeast and northwest. Its name is:
    a. Atlantic
    b. Atlantic Coast
    c. Canadian National
    d. Canadian Pacific
4. 27°55' 30" N and 81°37' W is closest to:
    a. Radio Station
    b. Lake Edward
    c. Lake Altamaha
    d. Lake Belle
5. Find Lake Effie. Find Lake Wales. If you went from Lake Effie to Lake Wales, you would be going:
    a. northwest
    b. northeast
    c. southeast
    d. southwest
6. Find Canal. Canal runs mostly in the following directions:
    a. north and south
    b. east and west
    c. southeast and northwest
    d. southwest and northeast
7. The latitude and longitude at the top right corner of the map is:
    a. 27°55' 30" N, 81°33' W
    b. 13°N, 36°W
    c. 820°/ 1' W
    d. 81°33' W, 27°55' 30" N

8. Find Twin Lakes. If you travel southeast from the center of it, you will reach:

a. Lake Belle

b. Lake Effie

c. Lake Serena

d. Lake Cooper

9. Look at the little black rectangles ∴ on the map. These stand for:

a. cars

b. cattle

c. buildings

d. hills

10. Find the symbols ■ in the middle of the map. They stand for:

a. hospital

b. church

c. school

d. gas station

11. Find this symbol ≐ on the map. It stands for:

a. grass

b. swamp

c. trees

d. wheat

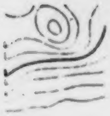
12. The red line marked 2 does not run absolutely straight because it has to go around a:

a. river

b. valley

c. lake

d. hill

13. There are many figures that look like this...  They stand for:
    - a. valleys
    - b. hills
    - c. lakes
    - d. holes

14. Look at the red line in the map that has 1 marked on it. The red line stands for:
    - a. the equator
    - b. a gravel road
    - c. a boundary
    - d. a paved road

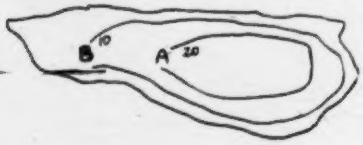
15. Find Lake Wales. It's height above sea level is:
    - a. 112 inches
    - b. 112 feet
    - c. 112 miles
    - d. 112 yards

16. Look at the areas on the map marked 1, 2, 3, 4. The flattest is:
    - a. 1
    - b. 2
    - c. 3
    - d. 4

17. Find the Lake Wales, Lake Effie, Lake Belle, and Lake Serena. The highest above sea level is:
    - a. Lake Wales
    - b. Lake Effie
    - c. Lake Belle
    - d. Lake Serena

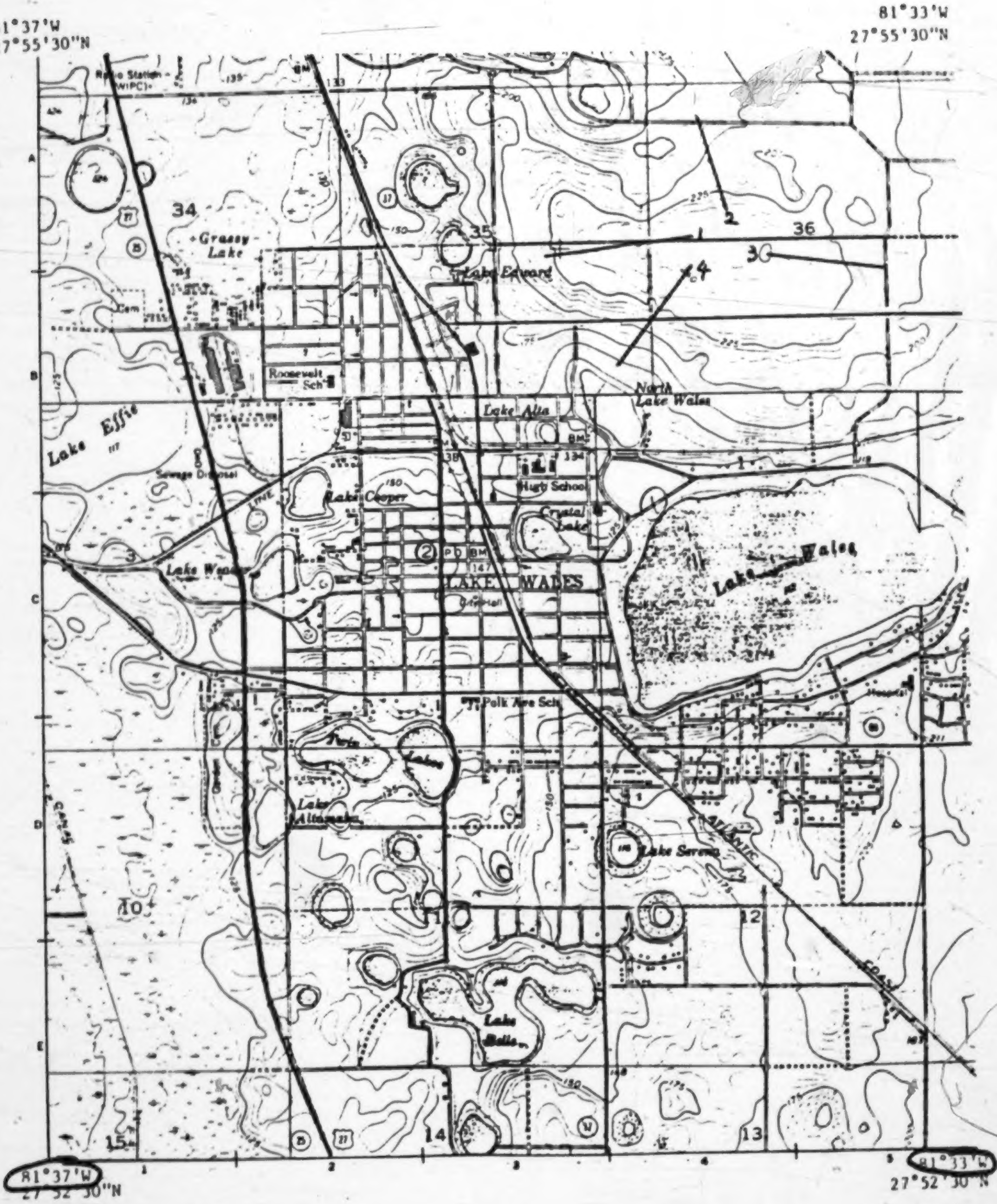
18. Look at the numbers that are circled at the bottom corners of the map. These stand for:
   - a. distance
   - b. longitude
   - c. latitude
   - d. elevation

19. Look at the island. Note that each line has been marked with numbers. Which one is the correct explanation about the island?



   - a. A is higher than B
   - b. B is higher than A
   - c. The distance between A and B is 10 feet
   - d. East side of the island is flatter than other sides.

20. A contour interval of 25 feet means that the ________ between the contour lines is 25 feet.
   - a. height
   - b. width
   - c. length
   - d. side-by-side


81°37'W
27°55'30"N
81°33'W
27°55'30"N
Radio Station (WIPC)
34
35
36
Grassy Lake
Lake Edward
Roosevelt Sch
Lake Effie
Sewage Disposal
Lake Alta
North Lake Wales
High School
Lake Cooper
Crystal Lake
LAKE WALES
Lake Wales
Polk Ave Sch
Twin Lakes
Lake Altamaha
Lake Serena
Lake Belle
10
12
13
14
15
1
2
3
4
81°37'W
27°52'30"N
81°33'W
27°52'30"N

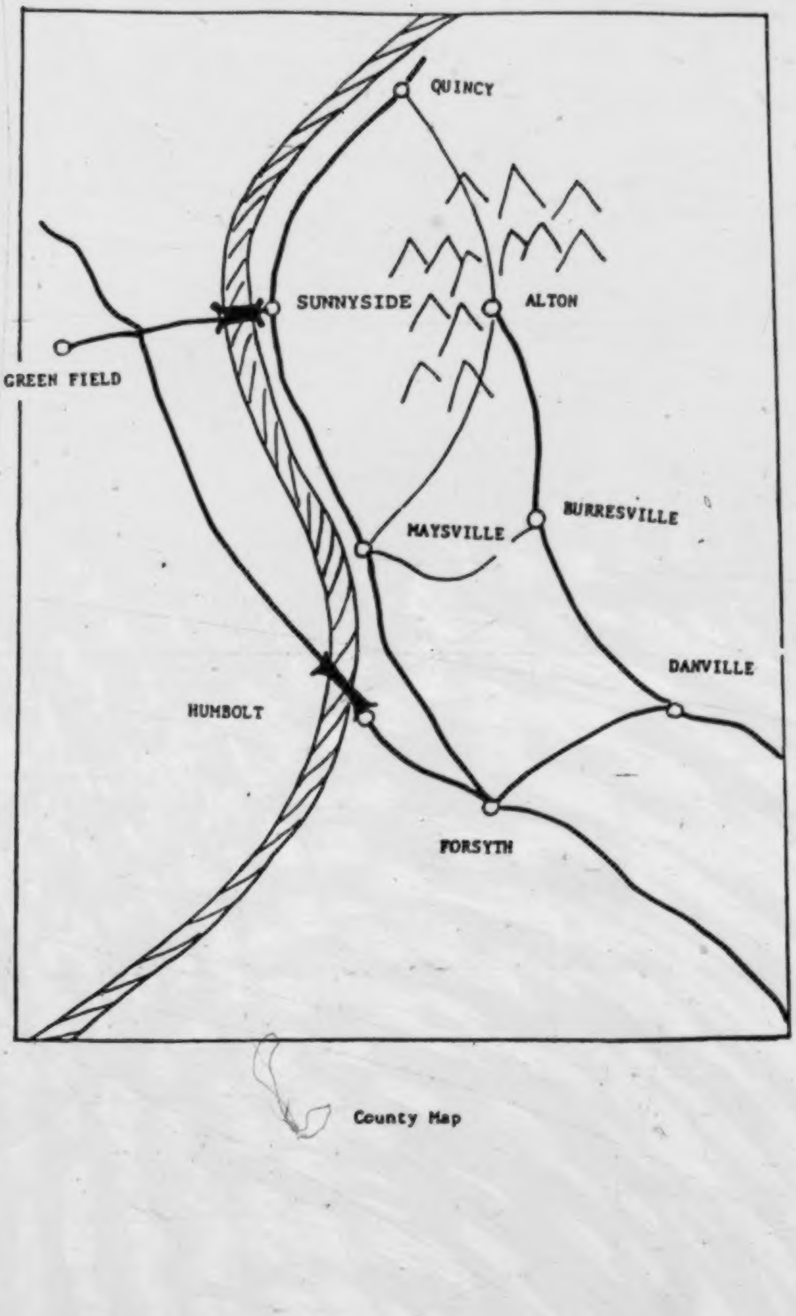
Appendix C: Experimental Tasks for Map Reproduction

1. Study maps

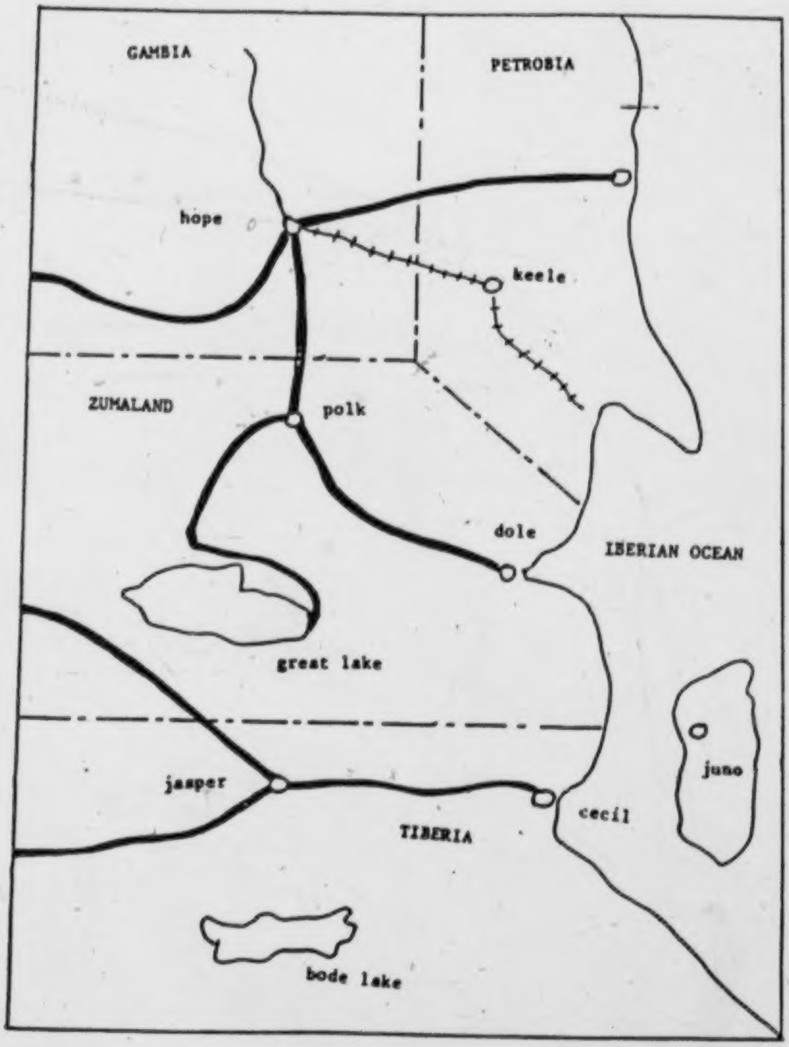
    Practice Map

    Countries Map

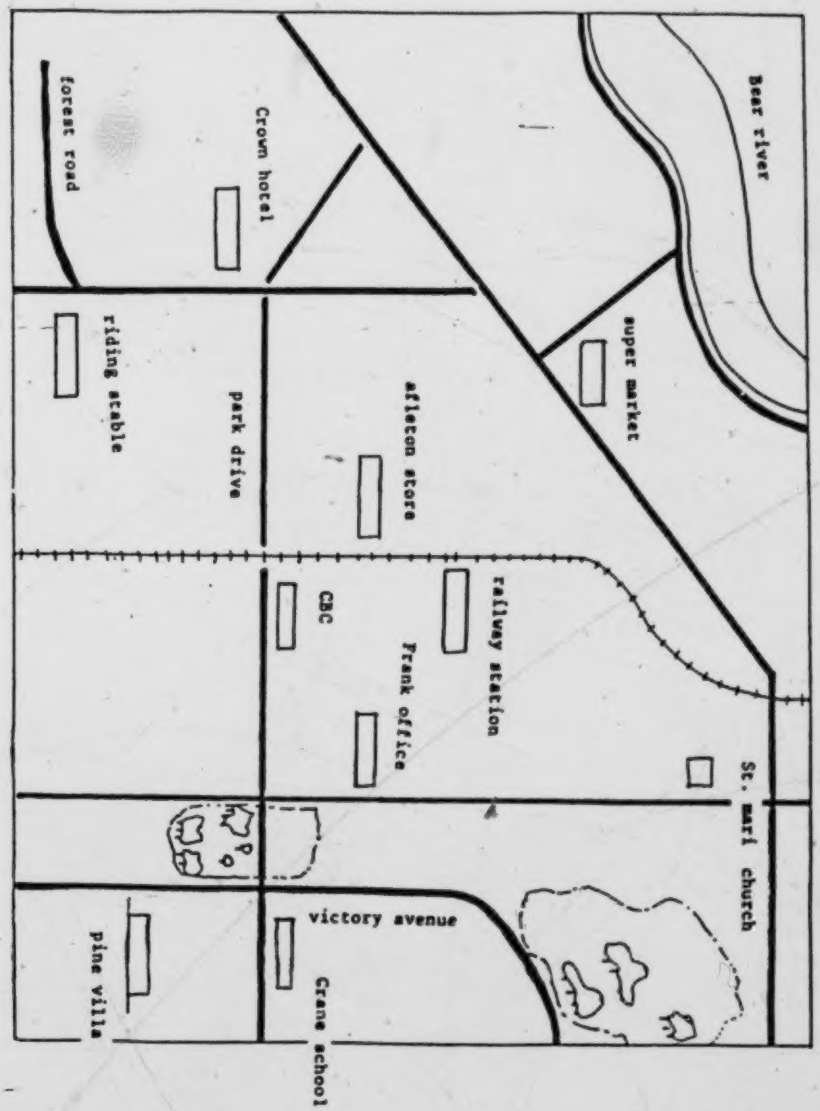
    Town Map


QUINCY
SUNNYSIDE
ALTON
GREEN FIELD
BURRESVILLE
MAYSVILLE
DANVILLE
HUMBOLT
FORSYTH

County Map


GAMBIA
PETROBIA
hope
keele
ZUMALAND
polk
dole
IBERIAN OCEAN
great lake
jasper
juno
cecil
TIBERIA
bode lake

Countries map


Bear river
forest road
Crown hotel
super market
riding stable
park drive
afleton store
railway station
CBC
Frank office
St. mari church
victory avenue
pine villa
Crane school

Town map

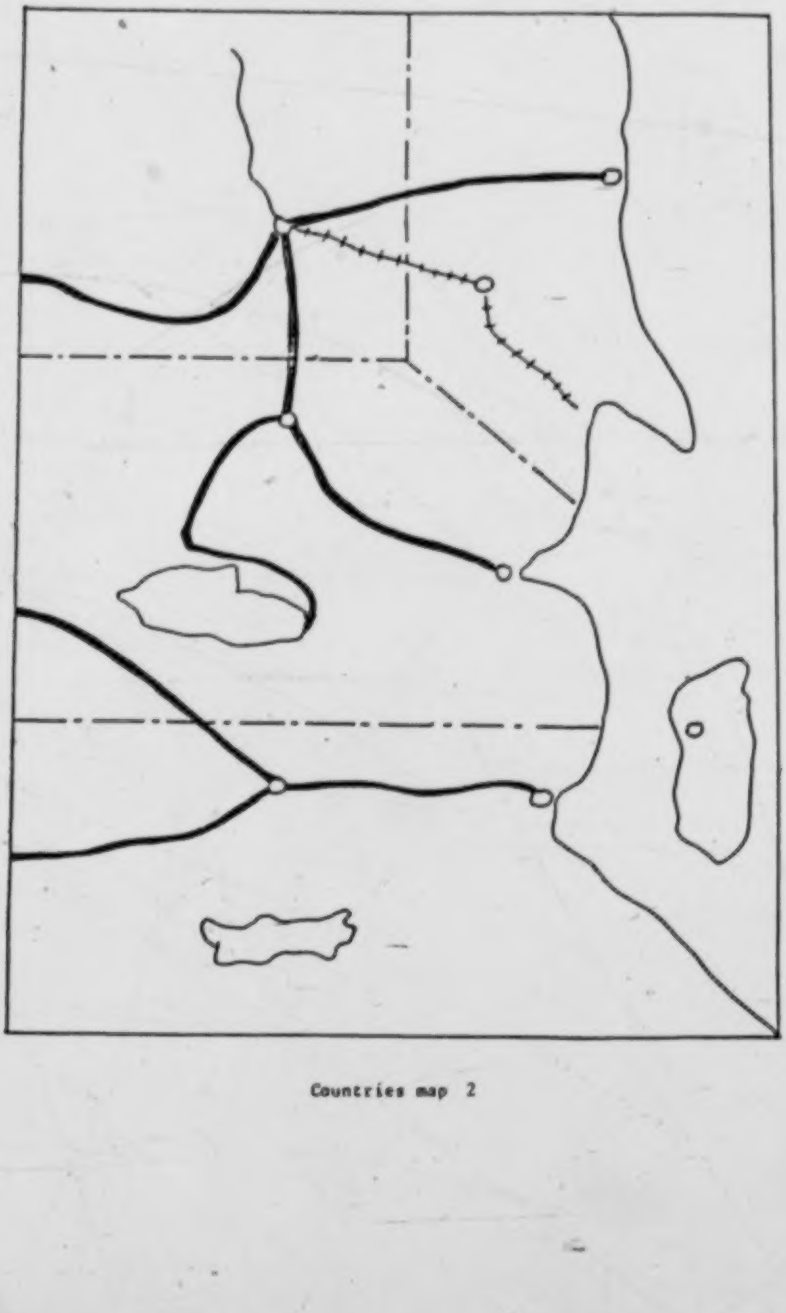
2. Answer Sheets

   Countries Map with Spatial Cues

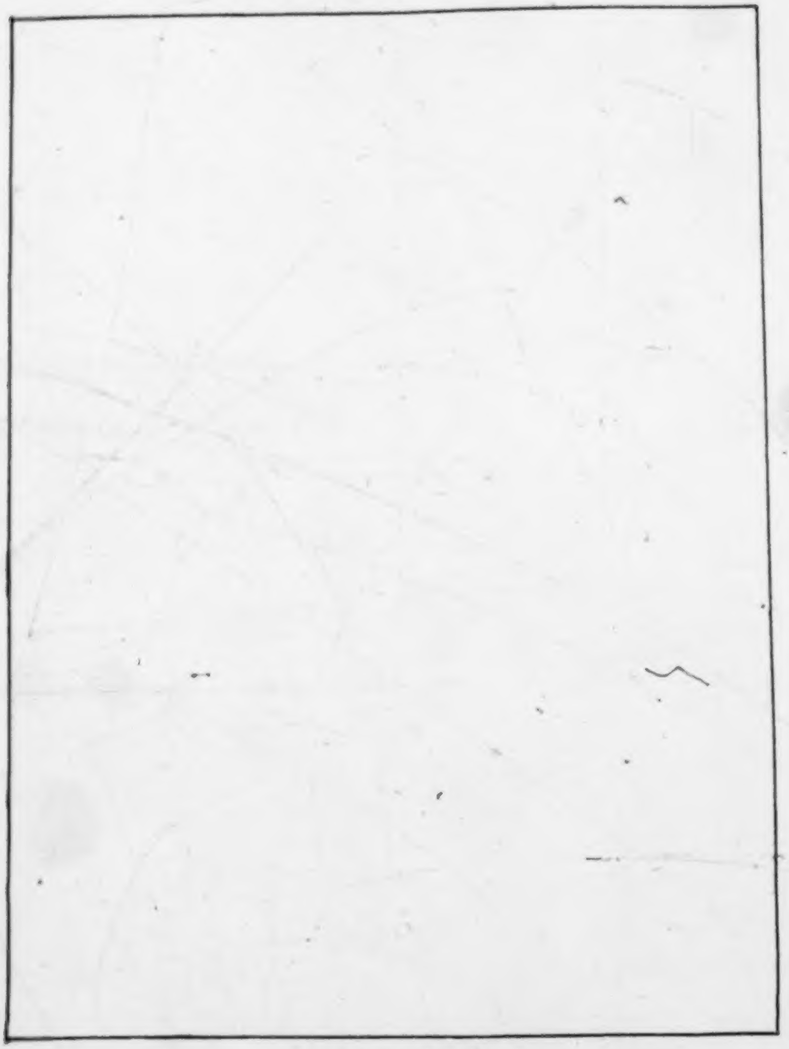
   Countries Map with Verbal Cues

   Town Map with Spatial Cues

   Town Map with Verbal Cues

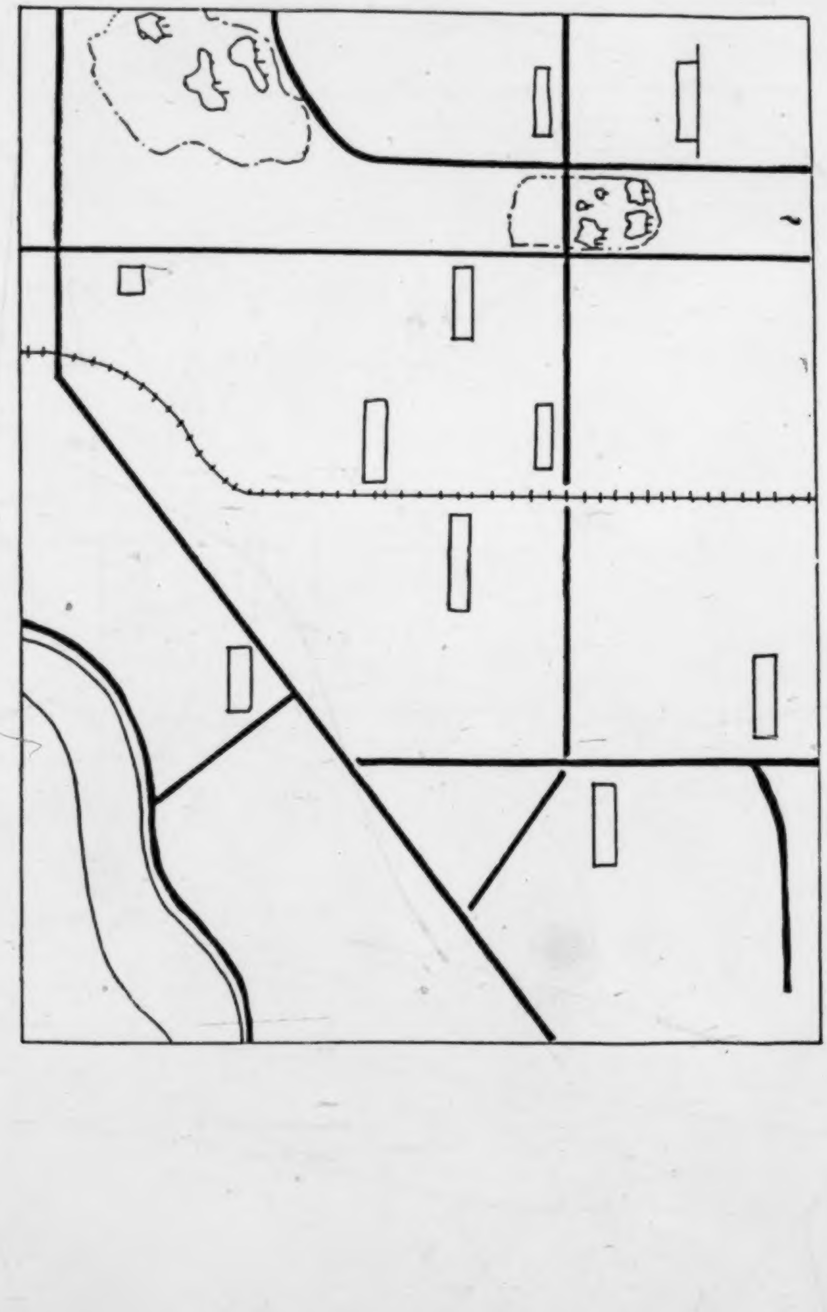


Countries map 2



Countries Map 1

1. arno
2. bode lake
3. cecil
4. dole
5. IBERIAN OCEAN
6. GAMBIA
7. great lake
8. polk
9. hope
10. jasper
11. juno
12. keele
13. PETROBIA
14. TIBERIA
15. ZUMALAND



Town map 1

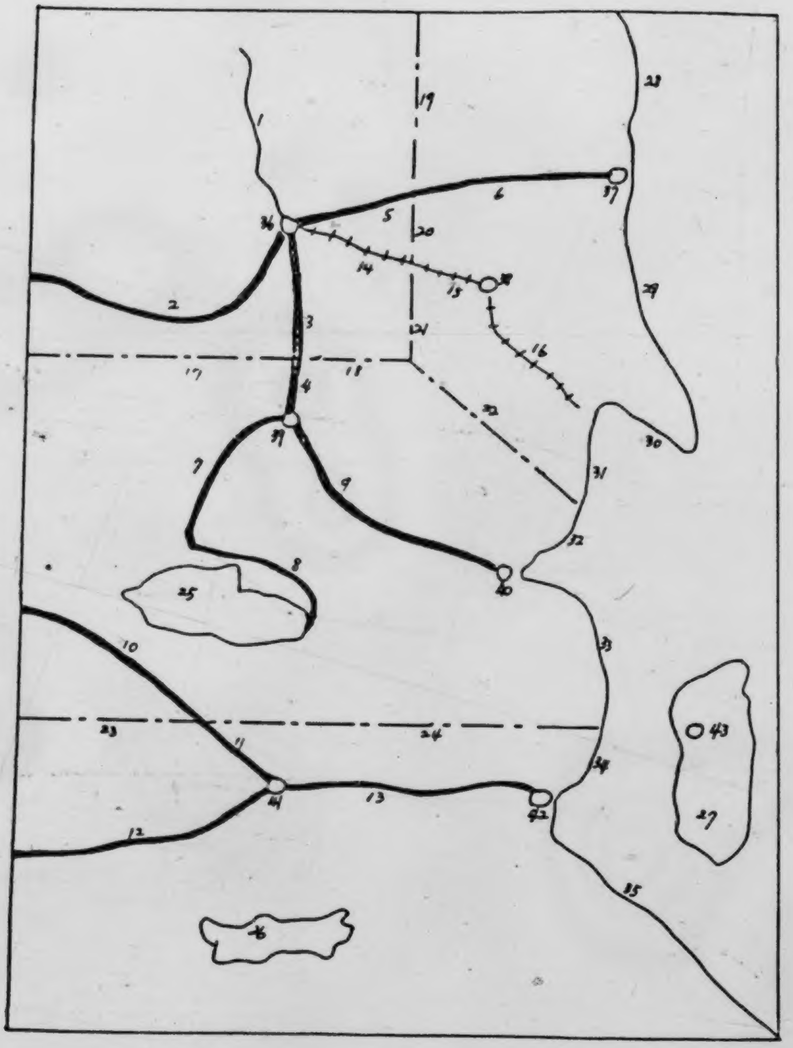
Town map 1

1. afleton store
2. Bear river
3. CBC
4. Crane school
5. Crown hotel
6. forest road
7. Frank office
8. park drive
9. pine villa
10. railway station
11. riding stable
12. St. mari church
13. super market
14. victory avenue

3. Segmentation of Map Elements

    Countries Map

    Town Map


1
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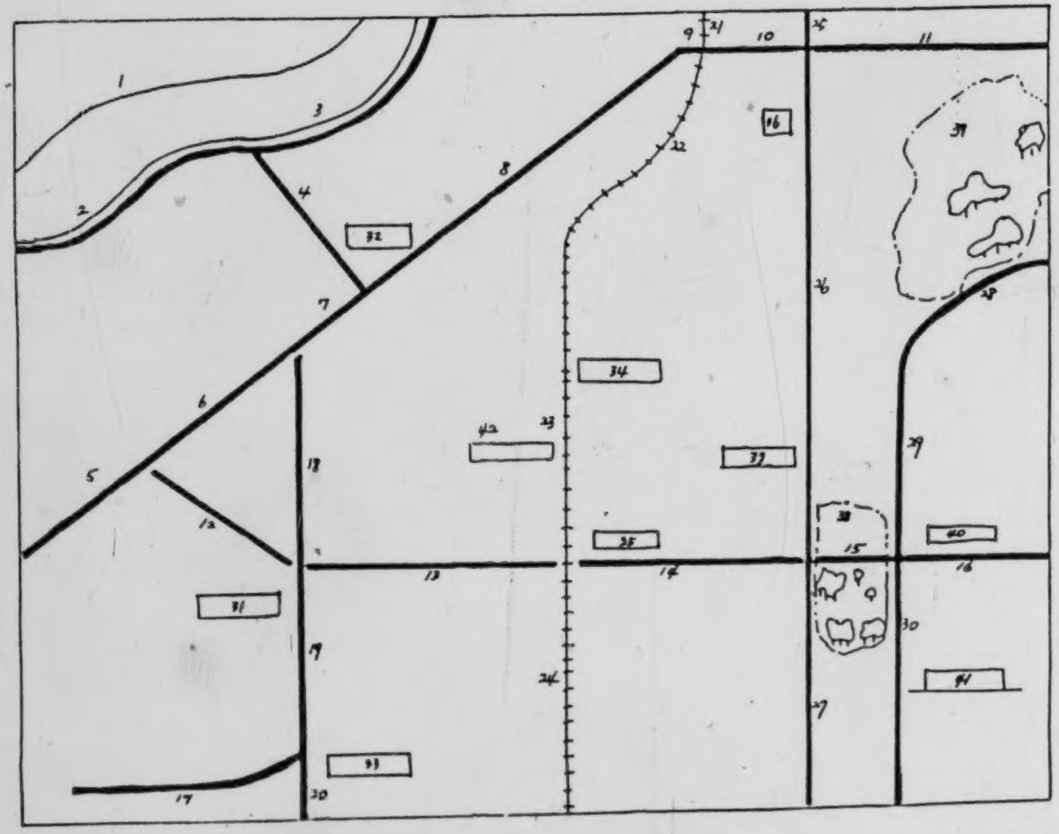
44

Countries map I


9
21
10
25
11
1
3
36
22
37
2
4
32
8
7
26
28
34
6
42
23
39
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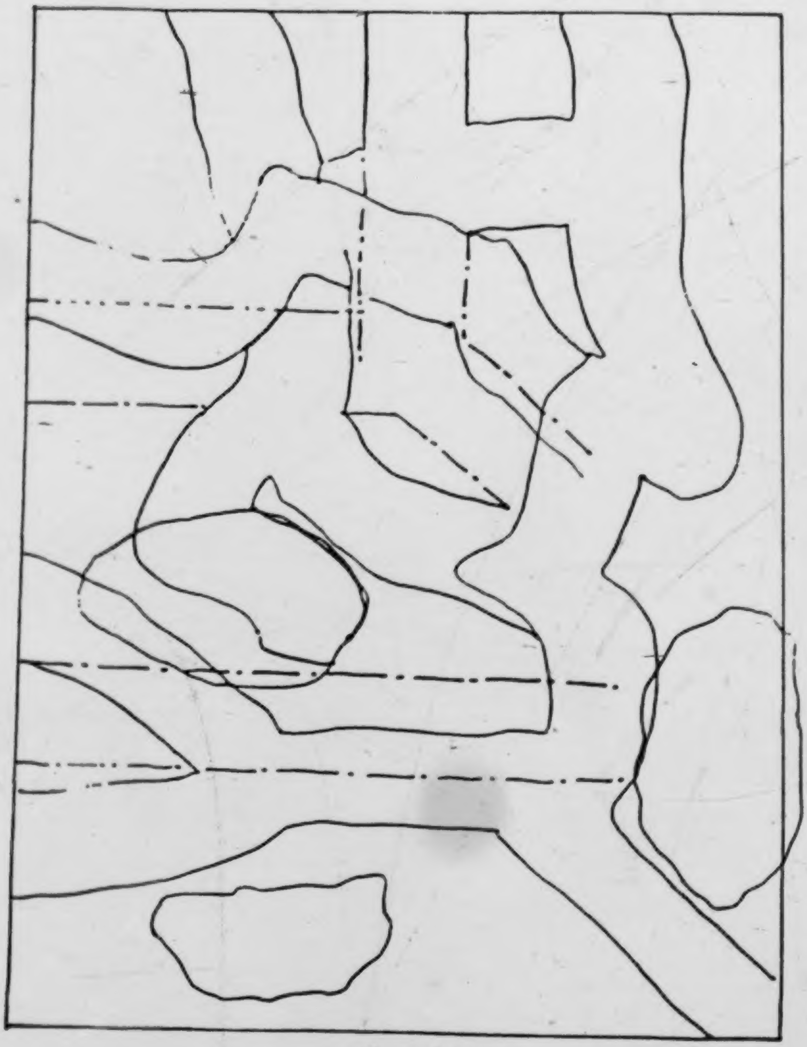
Town map

4. Measurement Map of Correct Placement of Spatial Elements

    Countries Map

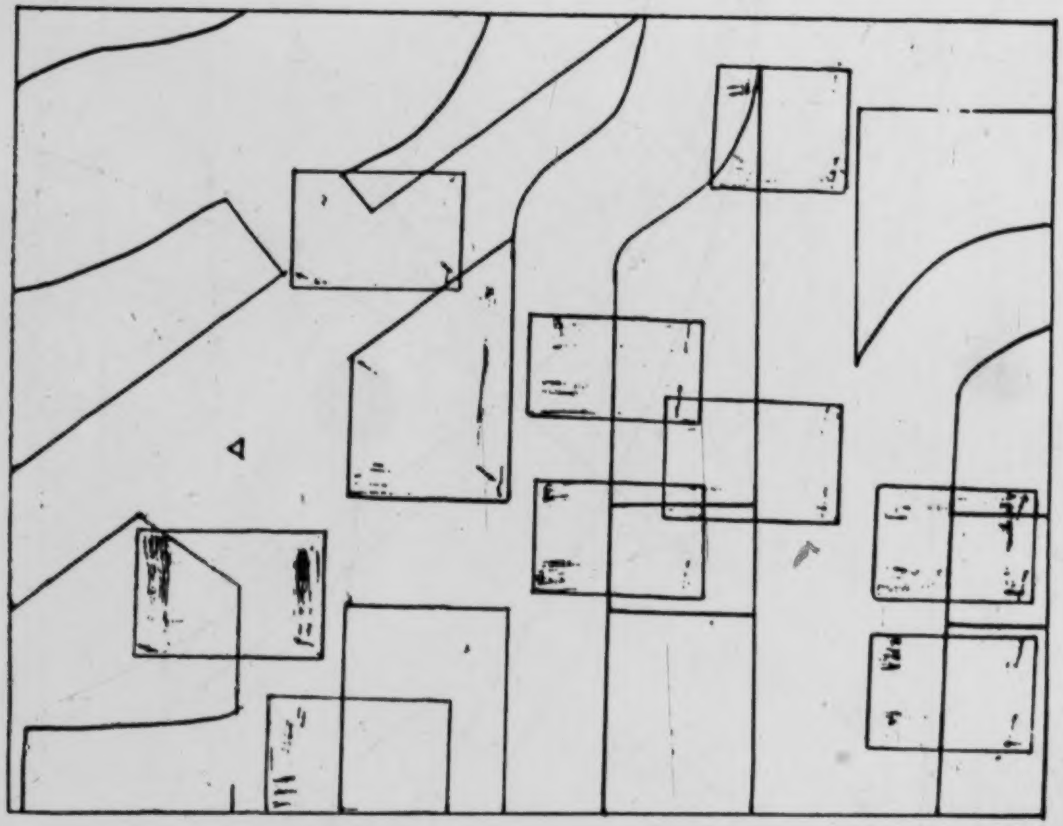
    Town Map

    Scoring Sheet



Countries Map

1. arno
2. bode lake
3. cecil
4. dole
5. IBERIAN OCEAN
6. GAMBIA
7. great lake
8. polk
9. hope
10. jasper
11. juno
12. keele
13. PETROBIA
14. TIBERIA
15. ZUMALAND



1. afleton store
2. Bear river
3. CBC
4. Crane school
5. Crown hotel
6. forest road
7. Frank office
8. park drive
9. pine villa
10. railway station
11. riding stable
12. St. mari church
13. super market
14. victory avenue

Scoring Sheet on Map Learning

Town Map
Unlabeled Spatial Information

	1		2		3		T	
	A	R	A	R	A	R	A	R
1		3						
2		2						
3		2						
4		3						
5		2						
6		3						
7		3						
8		2						
9		3						
10		5						
11		3						
12		3						
13		5						
14		5						
15		6						
16		3						
17		2						
18		4						
19		4						
20		2						
21		3			36		4	
22		3			37		4	
23		3			38		5	
24		3			39		4	
25		3			40		4	
26		5			41		4	
27		3			42		4	
28		3						
29		3						
30		3						
31		5						
32		4						
33		4						
34		3						
35		4						
T								

Countries Map
Verbal Information

	1		2		3		T	
	V	S	V	S	V	S	V	S
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2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
T								

Labeled Spatial Information

	1		2		3		T	
	A	R	A	R	A	R	A	R
1		4						
2		3						
3		4						
4		4						
5		5						
6		2						
7		4						
8		5						
9		4						
10		3						
11		4						
12		4						
13		4						
14		4						
15								

Name____________

____

School____________

Date____________

Condition____________

Scoring Sheet on Map Learning

Unlabeled Spatial Information

	1		2		3		T	
	A	R	A	R	A	R	A	R
1								
2								
3								
4								
5								
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32								
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34								
35								
T								

Verbal Information

	1		2		3		T	
	V	S	V	S	V	S	V	S
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14								
15								
T								

Name______________

______ ______

School____________

Date______________

Condition_________

Labeled Spatial Information

	1		2		3		T	
	A	R	A	R	A	R	A	R
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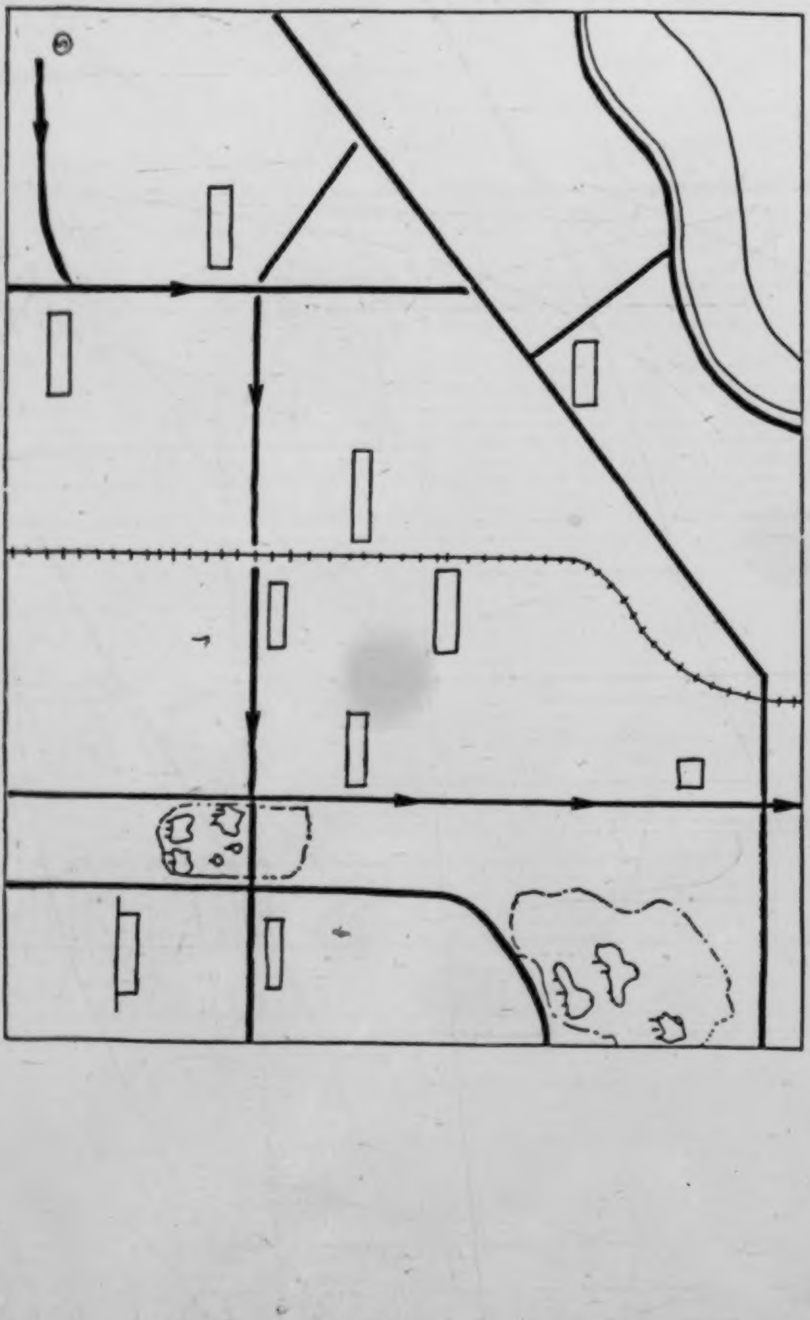
Appendix D: Navigation Problem Solving

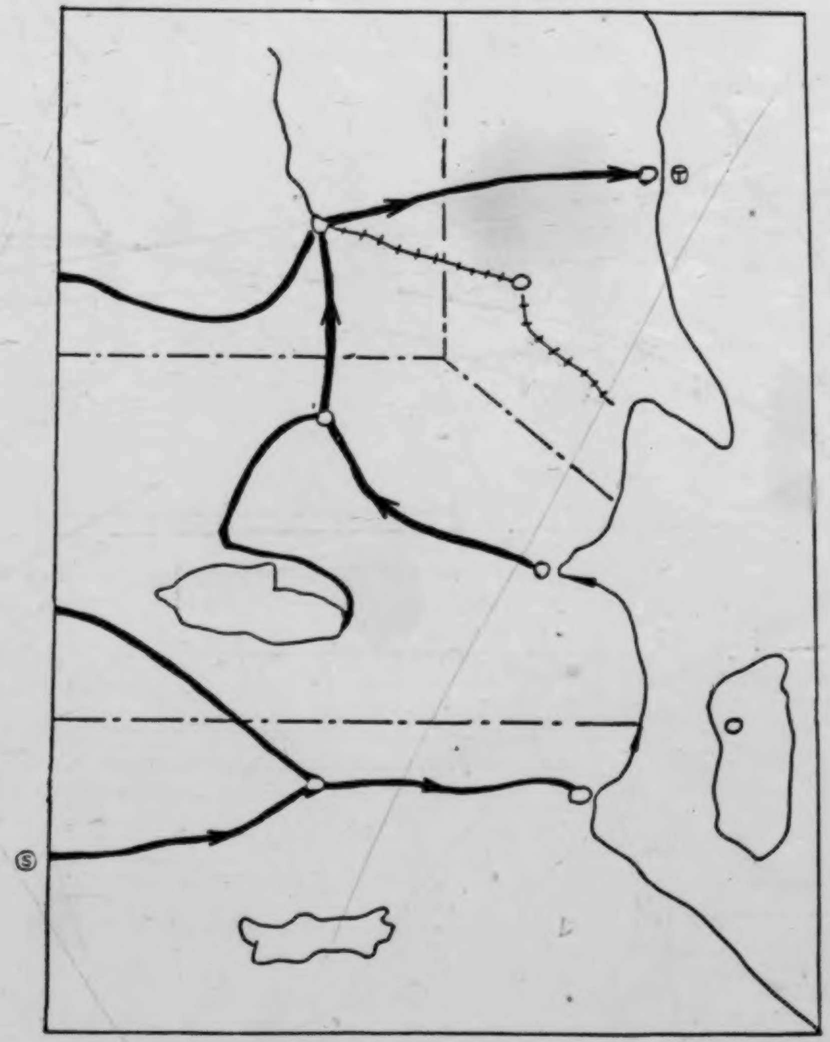
1. Computer Program
2. Problems: Routes of Circle Movement
3. Scoring Sheet

```
10    HGR 2: TEXT
20    DIM X(15), Y(15)
30    SCALE= 1: ROT=0: HCOLOR =2
40    GOSUB 790
50    A$(1) = "COUNTY"
60    A$(2) = "COUNTRY"
70    A$(3) = "TOWN'
80    A$  = "BLOAD"
90    PRINTA$;"S1": PRINT A$;'L1"
100   DATA   7,6,7,9,13,7,4,6,11
110   FOR I=1 TO 9: READ R(I):NEXT I
120   DATA 160,140,132,103,115,113,101,107,82,60,90,33,109,15
130   DATA 40,67,55,63,77,106,100,140,124,160,160,140
140   DATA 128,60,119,85,101,107,115,113,132,103,160,140,124,160
150   DATA 26,170,70,162,78,156,131,157,123,113,98,105,81,85,81,45,147,35
160   DATA 87,121,80,113,60,108,73,84,81,85,98,105,123,113,38,100
170   DATA 140,82,120,65,120,57,81,45,70,10
180   DATA 158,188,131,157,143,147,143,128,123,113,138,100,105,71
190   DATA 137,184,137,66,165,50,167,124,40,178,70,178,82,170,82,137,184
200   DATA 137,184,24,40,68,75,50,96,82,51,114,82,137,137,137,137,184,202.
205   DATA 184,202,94,217,84,232,86
210   TEXT: FOR I=1 TO 3: FOR J = 1 TO 3
220   HOME
230   VTAB 10: PRINT "STUDY THE FOLLOWING MAP!": PRINT : PRINT :
235   PRINT: PRINT "PRESS SPACE BAR WHEN DONE": PRINT A$;A4(I);",A$4000"
240   GOSUB 850
250   GOTO 280
260   POKE - 16304,0: POKE - 16302,0: POKE - 16299,0: POKE - 16297,0
270   RETURN
280   GET Z$
290   TEXT
300   PRINT "DRAW THE MAP!": PRINT : PRINT : PRINT: PRINT "PRESS
      SPACE BAR WHEN DONE.": GOSUB 890: GET Z$
310   HOME
320   NEXT J,I
330   VTAB 10: FOR I = 1 TO 3: FOR J = 1 TO 3J
340   VTAB 10: PRINT "WATCH THE CIRCLE": PRINT A$;A$(I);",A$4000'
350   GOSUB 260
360   GOSUB 520
370   TEXT
380   VTAB 10: PRINT "ON YOUR MAP"; (I - 1) * 3 + J; "DRAW THE PATH OF THE CIRCLE."
390   PRINT : PRINT: PRINT
400   PRINT "WHEN DONE PRESS SPACE BAR:: GOSUB 910: GET Z$: HOME
410   NEXT J,I
420   PRINT "OPEN ";UP$
430   PRINT "WRITE ";UP$
440   PRINT U1
450   PRINT U2$
```

```
460   PRINT U1$
470   PRINT SX(1): PRINT SX(2): PRINT SX(3): PRINT SG(1): PRINT SG (2):
480   PRINT SG(3): PRINT SP(1,1): PRINT SP(2,1): PRINT SP(3,1): PRINT SP(1,2):
490   PRINT SP(1,2): PRINT SP(2,2): PRINT SP(3,2): PRINT SP(1,3)
500   PRINT SP(2,3): PRINT SP(3,3)
510   END
520   Z=R((I-1) * 3 + J)
530   FOR P = 1 TO Z
540   READ X(P), Y(P)
550   NEXT
560   FOR P=1 TO Z -1
570   IF ABS (X(P+1) - X(P) = < ABS (Y(P+1) - Y(P)) THEN 590
580   GOTO 600
590   GOTO 570
600   E = (Y(P+1) - Y(P))/(X(P+1) - X(P))
610   G = SGN (X(P+1) - X(P))
620   H'= SGN (Y(P+1) - Y(P))
630   U = (X(P+1) - X(P)
640   FOR M = O TO U STEP G
650   XDRAW 1 AT X(P) + (M), Y(P)+ (M* E)
660   FOR W = 1 TO 10: NEXT
670   XDRAW 1 AT X(P) +(M),Y(P) + (M*E)
680   NEXT M,P
690   RETURN
700   E = (X(P+1) - X(P))/ Y(P+1) -Y(P))
710   G = (SGN (X(P + 1) - X(P)): H = SGN (Y(P + 1) - Y(P))
720   U = ( YU(P+1-Y(P))
730   FOR M = O TO U STEP H
740   XDRAW 1 AT X(P) + (M + E), Y(P)+ (M)
750   FOR W = 1 TO 10: NEXT
760   XDRAW 1 AT X(P) +(M*E),Y(P) + (M)
770   NEXT M,P
780   RETURN
790   TEXT : HOME : INPUT "HELLO, WHAT IS YOUR NAME?            "; UP$
800   INPUT "WHAT SCHOOL DO YOU GO TO?; U1$
810   INPUT "HOW OLD ARE YOU ?";U1
820   INPUT "WHAT GRADE  ARE YOU IN?";U2$
830   PRINT "HAVE FUN."
840   RETURN
850   GOSUB 260: FOR UT = 1 TO 790:IF PEEK ( -16384)> 127 THEN SX(1) = UT: RETURN
860   NEXT UT
870   GOSUB 260: FOR UT = SX(1) TO 790:IF PEEK ( -16384)> 127 THEN SX(1) = UT:RETURN
880   NEXT UT
890   FOR UT = 1 TO  200000:IF PEEK ( - 16384)> 127 THEN SG(I) = UT: RETURN
900   NEXT UT
910   FOR UT = 1 TO  200000:IF PEEK ( - 16384)> 127 THEN SP(I,J) = UT: RETURN
920   NEXT UT
```



Town map 1



Countries map 1

NAVIGATION PROBLEM SOLVING: SCORING SHEET

NAME________________________________

School______________________________

condition___________________________

COUNTRIES

A.

__ From the road
__ go East
__ pass Jasper
__ Turn Right
__ go East
__ turn Left
__ go up North
__ pass Dole
__ turn Left
__ go up Northwest
__ pass Polk
__ turn Right
__ go up North
__ Pass Hope
__ turn Right
__ go East
__ stop at Arno

T

B.

__ from Great lake
__ go up North
__ pass Polk
__ turn Right
__ go down Southeast
__ pass Dole
__ turn Left
__ go North
__ along the coast
__ turn Left
__ go Northwest
__ pass Keele
__ keep on going
__ pass Hope
__ go up North

T

C.

__ from the Bottom
__ follow the coast
__ pass Cecil
__ keep on going North
__ pass Dole
__ turn Left
__ follow the borderline
__ stop there

T

TOWN

A.

__ from the bottom
__ of the railroad track
__ go to North
__ follow the railroad track
__ pass CBC
__ pass Afleton store
__ pass railway station
__ turn Right
__ go East
__ pass St. mari church
__ turn Left
__ go North
__ stop there

T

B.

__ from the forest road
__ go East
__ pass Riding stable
__ turn Left
__ go North
__ pass crown hotel
__ turn Right
__ go East
__ follow park drive
__ pass railroad track
__ pass CBC
__ turn Left
__ go North
__ pass Frank office
__ pass St. mari church
stop at the top

C.

__ along the Bear river
__ turn Right
__ go down along the short road
__ down to Southwest
__ pass super market
__ turn Right
__ go down South west
__ turn Left
__ down to Southeast
__ at the intersection
__ pass crown hotel
__ turn Left
__go along the park drive
__ at the railroad track
__ turn Right
__ go down to South
__at the bottom
__ turn Left
__ at the Second intersection
__ turn Left
__ go North
__ follow the victory avenue
__ pass Pine villa
__ pass Crane school
__ turn Right

Appendix E: Instruction for Experimental Procedure

Instruction for Reproduction of Map

"You are going to study two maps shown on the screen of the computer for one minute. One map has buildings and roads, and the other map has countries and cities. Please study the map shown on the screen carefully. After one minute the map goes off from the screen, then I will give you a paper where you either draw the lines or write down the names of the cities or buildings. You may take as much time as you need to write or draw. When you think you cannot remember any more, you can study the same map again by pressing the space bar of the computer. Since it is not easy to remember all the information on the map at once, you will repeate studying and drawing three times for each map.

You will be given one of the two different kinds of answer sheets. One has all the names of the objects on the map, and the other one has all the lines of the roads and border lines. When you are given an answer sheet with all the names of the things in the map, you will draw the lines. When you draw, the important thing is where buildings or cities are located rather than how it looks like. When you are given an answer sheet with all the lines, you will write down the names. To remember the names correctly is important to find some places. Same kind of answer sheets will be given for each map. After studying and writing one map three times, you will continue to the next map. Before you start the real study, you will see a map with which you can get to know how and what to study."

"By the way, when you study, I believe that you think alot. Do you think silently or making some kind of sounds, like murmuring to yourself or like talking to yourself?"

(1) If the subject says yes,

"Ok. I would like to know how you study or what you think when you study. Can you to talk to yourself as when you study all by yourself. If you don't think aloud, I cannot either hear or see. Then, it is difficult for me to figure out what's going on in your mind. Right? Please think aloud"

(2) If the subject says no,

"I believe you think alot when you study. The only thing that you have to do is just to make your thinking sounded. Ok? You may sometimes have seen some of your friends talking to themselves when they are studying. Like those friends, I want you to talk to yourself whatever comes into your mind or whatever is going on in your mind studying the map. If you don't think aloud, I don't know how you study and what you think. Can you make you thinking sounded, so that I know what you study and how you study. Since you will have a practice, you can try.

"Now, you can press the space bar of the computer to start studying the map."

Instruction for navigation problem solving

"Now, I am going to show you the same maps again, but you will see a small circle moving. It moves along a route and stops at a city or building. After the circle stops,the map goes off. Then, you tell me where the circle started and passed and arrived. You will tell me not only the places but also the directions. You will see a circle moving three times for each map." "Let me ask you a question, before we start. When you ask one of your new friends to come over to your place, how do you show your friend the way to find your place?"

(1) If the subject describes the way including the directions and the landmarks to make turns,

"Right, You tell them the directions and how many blocks and what kinds of buildings to pass and where to make turns.."

(2) If the subject does not describe properly,

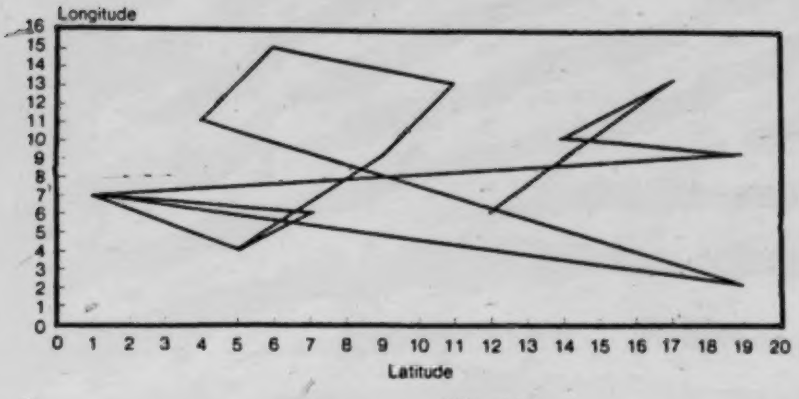
"Ok, if somebody asks you how to find your school from the bank (a landmark close to the school is used), how do you show the way to them? Does the person have to cross the street? Does the person have to turn to right and go straight until s/he finds a sign of your school?"

(After confirming subject's awareness of the requirements of the task) "Alright, now you know how to show the ways either to your school or your place."

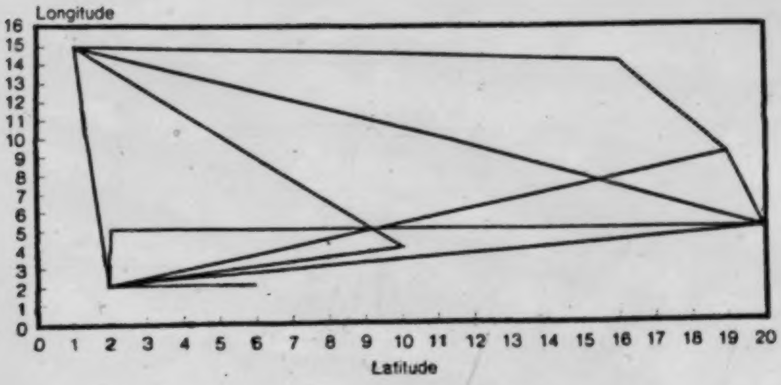
"Now, this is a practice. Look at the circle carefully and remember where it went through and which direction it followed. Ok? If you are ready, press space bar to start."

Appendix F: Examples of Sampling Strategies

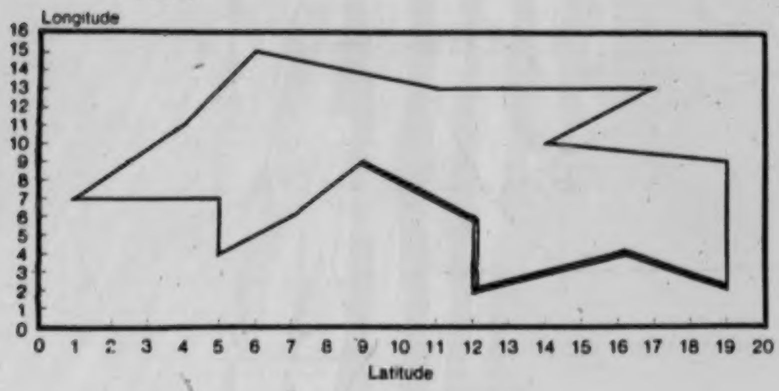
1. Random Sampling
2. Systematic Sampling
3. Regionally-Focused Sampling



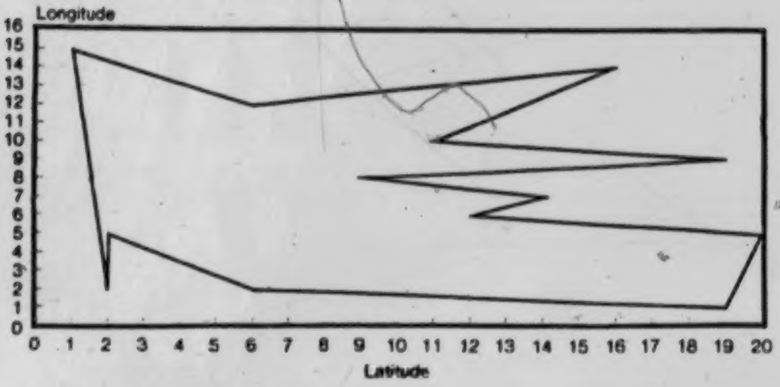
• Countries



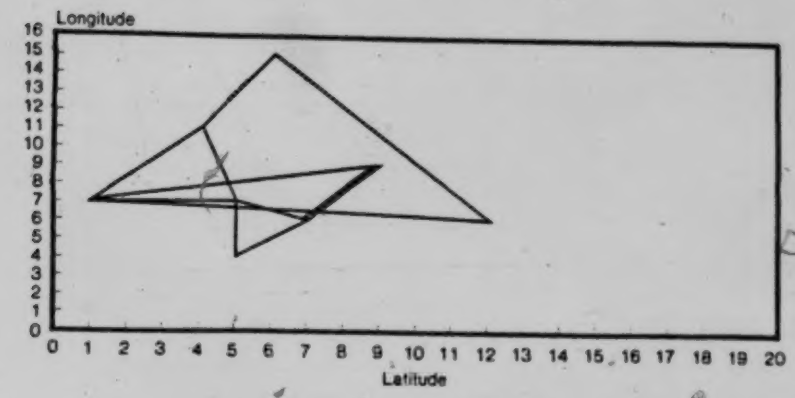
• Town



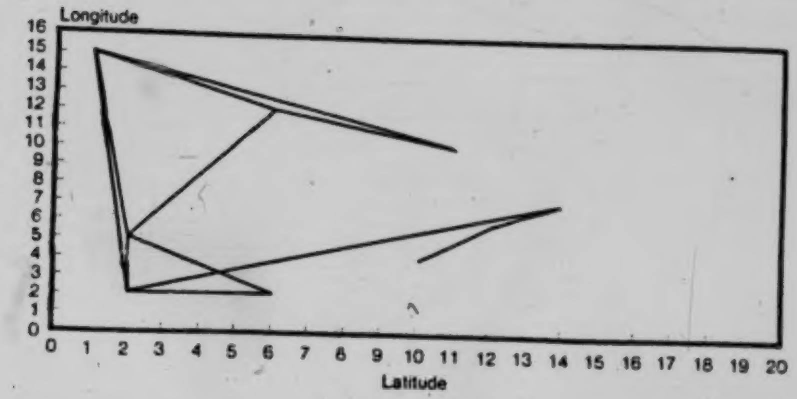
* Countries



* Town



* Countries



* Town

Appendix G: Strategy Assessment Form

STRATEGY ASSESSMENT

Name __________________________

School __________________________

	1		2		3		1		2		3	
Sampling												
random												
systematic												
regionally-focused												
Encoding												
Verbal												
kinesthetic												
counting												
rehearsal												
Spatial												
kinesthetic												
recognition												
labeling												
elaboration												
Relational												
individual												
general												
Retrieval												
separate												
main frame												
Monitoring												
Evaluation												
positive												
negative												
task												
Cues utilization												
cross-out												

Appendix H: Summary of Statistical Analysis

1. Subjects Profile
2. Group Differences in Recall and Learning
3. Group Differences in Strategies Use
4. Intercorrelations

1. Subjects Profile

1.1 Means and Standard Deviations

Varbls	Giftd(21) Mean(SD)	Avrge(17) Mean(SD)	L.D.(14) Mean(SD)	Total(52) Mean(SD)
IQV	134(7.7)	107(5.5)	91(28.1)	114(23.6)
IQQ	131(8.2)	104(8.7)	82(25.8)	109(25.1)
IQNV	127(13.2)	103(12.0)	84(25.3)	107(24.4)
READ DC	84(22.4)	46(28.4)	28(23.6)	57(34.3)
READ CP	90(21.1)	47(24.8)	23(19.4)	58(35.4)
MATH	57(2.2)	49(6.3)	34(11.2)	48(11.9)

1.2 Group Differences in Subjects Profile: Oneway ANOVA

Variable	MSH	MSE	F	df	p
Sex	0.7	0.2	3.11	2/49	0.053
Age	42.5	34.1	7.11	2/49	0.002
IQV	8269.3	243.9	33.90	2/49	0.000
IQQ	10420.5	228.4	45.60	2/49	0.000
IQNV	8157.6	288.3	28.30	2/49	0.000
Read DC	14845.8	617.2	24.05	2/49	0.000
Read CP	20119.1	485.0	28.29	2/49	0.000
Math	2414.8	48.2	50.11	2/49	0.000

1.3 Duncan's Multiple Range Test

Varibl	Cont	Diffncs	SE	t	df	p
Sex	1	-0.4	0.16	-2.44	49	0.02
	2	-0.2	0.16	-1.49	49	0.14
	3	-0.2	0.17	-1.00	49	0.32
Age	1	-7.3	2.02	-3.64	49	0.001
	2	-4.6	1.91	-2.43	49	0.19
	3	-2.7	2.11	-1.28	49	0.21
IQV	1	42.9	5.29	7.97	49	0.00
	2	26.8	5.10	5.26	49	0.00
	3	16.1	5.64	2.86	49	0.00
IQQ	1	49.2	5.22	9.44	49	0.00
	2	26.3	4.93	5.33	49	0.00
	3	22.9	5.45	4.21	49	0.00
IQNV	1	43.4	5.86	7.41	49	0.00
	2	23.9	5.54	4.32	49	0.00
	3	19.5	6.13	3.18	49	0.003
Read DC	1	56.6	8.57	6.61	49	0.00
	2	38.1	8.11	4.71	49	0.00
	3	18.5	8.96	2.06	49	0.04
Read CP	1	66.8	7.60	8.79	49	0.00
	2	42.3	7.19	5.88	49	0.00
	3	24.5	7.95	3.08	49	0.003
Math	1	23.9	2.39	9.91	49	0.00
	2	8.3	2.26	3.64	49	0.001
	3	16.7	2.51	6.26	49	0.000

Note: Contrast 1 = Gifted vs Learning Disabled
Contrast 2 = Gifted vs Average
Contrast 3 = Average vs Learning Disabled

2. Recall Performance

2.1 Group Differences in Recall across Trials

2.1.1 Means and Standard Deviations

Variables	Giftd(21) Mean(SD)	Avrge(17) Mean(SD)	L.D.(14) Mean(SD)	Total(52) Mean(SD)
Totl RC	55.9(11.4)	44.1(12.9)	40.2(8.5)	47.9(13.0)
Sptl RC	57.5(16.8)	43.3(11.5)	42.9(10.7)	48.9(15.2)
Labeled	65.5(17.4)	61.9(15.7)	58.6(12.8)	62.5(15.7)
Unlabld	49.5(20.6)	24.8(13.1)	27.2(13.3)	35.4(20.1)
Verbal RC	54.3(14.0)	44.9(18.4)	7.6(13.3)	46.7(16.6)

2.1.2 Oneway ANOVA

Variables	MSH	MSE	F	f	p
Totl RC	4805.8	506.2	9.49	2/49	0.0003
Spatial RC	1290.9	189.3	6.82	2/49	0.002
Labeled	203.7	247.4	0.83	2/49	0.44
Unlabld	3516.4	276.2	12.70	2/49	0.000
Verbal RC	1210.6	237.5	5.10	2/49	0.010

2.1.3 Analysis of Variance on Spatial Recall with Quantitative Intelligence as Covariates between Average and Learning Disabled Subjects

Source	MSH	df	F	p
Within Cells	126.0	28		
Regression	79.3	1	0.63	0.43
Constant	1325.3	1	10.52	0.003
Group	14.2	1	0.12	0.74

2.1.4 Regression Anlysis for Within Cells Error Term
Dependent Variable ....Spatial Recall

Covariate	B	Beta	Std.Err.	t	p
Qunt. Intlgnc	0.89	148	0.113	0.794	0.43

2.1.5 Duncan's Multiple Range Test

Variables	Cont	Diffncs	SE	t	df	p
Total RC	1	31.3	7.76	4.03	49	0.00
	2	23.6	7.34	3.20	49	0.002
	3	7.7	8.12	0.95	49	0.35
Spatial	1	14.6	4.74	3.08	49	0.003
	2	14.2	4.49	3.15	49	0.003
	3	0.4	4.97	0.08	49	0.93
Labeld	1	6.9	5.43	1.27	49	0.21
	2	3.6	5.13	0.70	49	0.49
	3	3.3	5.68	0.58	49	0.56
Unlabd	1	22.3	5.70	3.89	49	0.00
	2	24.7	5.40	4.56	49	0.00
	3	-2.4	6.00	-0.40	49	0.69
Verbal	1	16.7	5.30	3.14	49	0.003
	2	9.4	5.00	1.87	49	0.07
	3	7.3	5.60	1.31	49	0.20

Note: Contrast 1 = Gifted vs Learning disabled
Contrast 2 = Gifted vs Average
Contrast 3 = Average vs Learning Disabled

2.2 Group Differences in Recall Over Trials

2.2.1 Means and Standard Deviations

Variables	Giftd(21) Mean(SD)	Avrge(17) Mean(SD)	L.D.(14)) Mean(SD)	Total(52) Mean(SD)
Total Recall				
Trial 1	35.8(11.2)	29.9(11.6)	25.4(7.3)	31.1(11.1)
Trial 2	57.9(13.4)	44.3(14.2)	42.0(9.7)	49.2(14.5)
Trial 3	61.7(11.0)	48.9(13.2)	44.4(9.2)	52.9(13.4)
Spatial Recall				
Trial 1	42.8(15.9)	30.4(13.1)	28.8(12.2)	35.0(15.3)
Trial 2	56.5(18.8)	44.2(11.2)	46.0(11.9)	49.6(15.7)
Trial 3	48.8(13.2)	36.9(9.4)	36.0(8.0)	41.5(12.2)
Labeled Spatial Recall				
Trial 1	48.3(19.0)	47.0(22.3)	41.2(20.1)	45.9(20.2)
Trial 2	68.2(20.7)	64.1(19.1)	62.4(13.7)	65.3(18.3)
Trial 3	80.1(19.4)	74.7(12.8)	72.2(11.3)	76.2(15.6)
Unlabeled Spatial Recall				
Trial 1	37.4(22.1)	13.9(10.9)	16.3(10.1)	24.1(19.5)
Trial 2	44.7(22.4)	24.3(14.6)	29.6(17.0)	34.0(20.5)
Trial 3	66.4(25.3)	36.1(19.7)	35.7(18.6)	48.2(26.2)
Verbal Recall				
Trial 1	28.7(13.2)	29.4(16.5)	22.0(8.9)	27.1(13.6)
Trial 2	59.4(18.0)	44.4(20.7)	38.0(15.1)	48.7(20.1)
Trial 3	74.6(17.8)	60.8(20.8)	52.7(17.2)	64.2(20.5)

2.2.2 Oneway ANOVA

Variables	MSH	MSE	F	df	p
Total Recall					
Trial 1	1885.2	436.9	4.32	2/49	0.02
Trial 2	5457.8	655.8	8.32	2/49	0.0008
Trial 3	5675.4	513.1	11.45	2/49	0.0001
Spatial Recall					
Trial 1	1094.3	198.5	5.51	2/49	0.007
Trial 2	832.8	222.0	3.75	2/49	0.03
Trial 3	952.0	117.3	8.11	2/49	0.0009
Labeled Spatial					
Trial 1	220.9	416.6	0.53	2/49	0.597
Trial 2	161.1	342.6	0.47	2/49	0.63
Trial 3	286.7	240.4	1.19	2/49	0.31
Unlabeled Spatial					
Trial 1	3175.3	264.8	12.0	2/49	0.0001
Trial 2	2134.6	351.4	6.08	2/49	0.0044
Trial 3	5199.4	480.1	12.08	2/49	0.0001
Verbal Recall					
Trial 1	254.2	181.9	1.4	2/49	0.257
Trial 2	2154.6	333.9	6.5	2/49	0.003
Trial 3	2165.9	350.2	6.2	2/49	0.004

2.2.3 Duncan's Multiple Range Test

Varibl	Cont	Dffncs	SE	t	df	p
Total Recall						
Trial 1	1	20.8	7.21	2.89	49	0.006
	2	11.8	6.82	1.73	49	0.091
	3	9.0	7.54	1.20	49	0.24
Trial 2	1	31.9	8.34	3.61	49	0.001
	2	27.2	8.35	3.26	49	0.002
	3	4.7	9.24	0.57	49	0.62
Trial 3	1	34.8	7.82	4.45	49	0.00
	2	25.8	7.40	3.48	49	0.001
	3	9.0	8.18	1.10	49	0.28

Note: Contrast 1 = Gifted vs Learning disabled
Contrast 2 = Gifted vs Average
Contrast 3 = Average vs Learning Disabled

2.2.4 Duncan's Multiple Range Test

Variables	Cont	Dffncs	SE	t	df	p
Total Recall						
Trial 1	1	20.8	7.21	2.89	49	0.006
	2	11.8	6.82	1.73	49	0.091
	3	9.0	7.54	1.20	49	0.24
Trial 2	1	31.9	8.34	3.61	49	0.001
	2	27.2	8.35	3.26	49	0.002
	3	4.7	9.24	0.57	49	0.62
Trial 3	1	34.8	7.82	4.45	49	0.00
	2	25.8	7.40	3.48	49	0.001
	3	9.0	8.18	1.10	49	0.28
Spatial Recall						
Trial 1	1	14.1	4.86	2.89	49	0.006
	2	12.4	4.60	2.70	49	0.009
	3	1.6	5.08	0.33	49	0.75
Trial 2	1	10.5	5.14	2.04	49	0.047
	2	12.3	4.86	2.52	49	0.015
	3	-1.8	5.38	-.33	49	0.74
Trial 3	1	12.8	3.74	3.44	49	0.001
	2	11.9	3.54	3.36	49	0.002
	3	1.0	3.91	0.25	49	0.81
Labeled Spatial Recall						
Trial 1	1	7.0	7.04	0.99	49	0.323
	2	1.3	6.66	0.19	49	0.848
	3	5.8	7.37	0.78	49	0.44
Trial 2	1	5.8	6.39	0.91	49	0.366
	2	4.1	6.04	0.68	49	0.499
	3	1.7	6.68	0.25	49	0.80
Trial 3	1	7.8	5.35	1.46	49	0.15
	2	5.4	5.06	1.06	49	0.29
	3	2.5	5.60	0.44	49	0.66
Unlabeled Spatial Recall						
Trial 1	1	21.1	5.62	3.76	49	0.000
	2	23.5	5.31	4.43	49	0.000
	3	-2.4	5.87	-.42	49	0.68
Trial 2	1	15.1	6.47	2.34	49	0.024
	2	20.4	6.12	3.33	49	0.002
	3	-5.3	6.77	-.78	49	0.44
Trial 3	1	30.7	7.56	4.06	49	0.000
	2	30.2	7.15	4.23	49	0.000
	3	0.5	7.90	0.06	49	0.95

(Cont'd)

(Cont'd)

Verbal Recall						
Trial 1	1	6.7	4.65	1.45	49	0.154
	2	-0.6	4.40	-.15	49	0.885
	3	7.4	4.87	1.51	49	0.14
Trial 2	1	21.4	6.30	3.39	49	0.001
	2	14.9	5.96	2.51	49	0.016
	3	6.5	6.59	0.98	49	0.33
Trial 3	1	21.9	6.46	3.93	49	0.001
	2	13.9	6.11	2.27	49	0.027
	3	8.0	6.75	1.19	49	0.24

Note: Contrast 1 = Gifted vs Learning Disabled
Contrast 2 = Gifted vs Average
Contrast 3 = Average vs Learning Disabled

2.2.5 Main and Interaction Effects of Trials and Groups on Total Recall, Spatial Recall, and Verbal Recall

Sources	MSH	MSE	F	df	p
Total Recall					
Group vs Cases	12384.6	1371.3	9.03	2/49	0.0000
Trial vs T*C	28363.5	117.3	241.03	2/98	0.0000
G X T vs T*C	426.8	117.3	3.55	4/98	0.000
Spatial Recall					
Group vs Cases	2844.4	441.5	6.44	2/49	0.003
Trial vs T*C	2795.7	48.2	58.10	2/98	0.000
G X T vs T*C	17.3	48.2	0.35	4/98	0.84
Labeled Spatial Recall					
Group vs Cases	611.2	742.3	0.82	2/49	0.44
Trial vs T*C	12207.9	128.6	94.90	2/98	0.000
G X T vs T*C	28.7	128.6	0.22	4/98	0.92
Unlabeled Spatial Recall					
Group vs Cases	10549.3	828.6	12.70	2/49	0.003
Trial vs T*C	2795.7	48.2	58.10	2/98	0.000
G X T vs T*C	280.4	133.9	2.10	4/98	0.09
Verbal Recall					
Group vs Cases	3631.8	712.6	5.09	2/49	0.0097
Trial vs T*C	18029.4	76.7	235.10	2/49	0.000
G X T vs T*C	471.4	76.7	6.10	2/49	0.0001

Note: T*C is Trial by Cases

2.3 Verbal Recall with Different Errors

2.3.1 Means and Standard Deviations

Varbls	Giftd(21) Mean(SD)	Avrge(17) Mean(SD)	L.D.(14) Mean(SD)	Total(52) Mean(SD)
Spelling	6.5(8.6)	8.9(13.1)	4.8(9.2)	6.8(10.3)
Placemnt	32.0(29.9)	48.2(32.4)	59.0(49.2)	44.5(37.7)
Sp & Plc	143.5(44.6)	106.1(59.1)	80.9(44.0)	114.4(55.2)

2.3.2 One way ANOVA

Variables	MSH	MSE	F	df	p
Spelling	65.7	108.5	0.61	2/49	0.55
Placmnt	3228.7	1349.9	2.39	2/49	0.10
Spel & Pl	17368.2	2464.7	7.05	2/49	0.002

2.3.3 Duncan's Multiple Range Test

Variables	Cont	Diffncs	SE	t	df	p
Spelling	1	1.8	3.6	0.49	49	0.63
	2	-2.3	3.4	-0.69	49	0.49
	3	4.0	3.8	1.09	49	0.28
Placement	1	-27.0	12.7	-2.13	49	0.04
	2	-16.2	12.0	-1.35	49	0.18
	3	-10.8	13.3	-0.82	49	0.42
Spel & Pl	1	62.7	17.1	3.66	49	0.001
	2	37.4	16.2	2.31	49	0.025
	3	25.2	17.9	1.41	49	0.165

Note: Contrast 1 = Gifted vs Learning Disabled
Contrast 2 = Gifted vs Average
Contrast 3 = Average vs Learning Disabled

2.4.4 Main and Interaction Effects of the Trials and the Group on Verbal Recall with Correct Spelling, Correct Placement, and Correct Spelling and Placement

Sources	MSH	MSE	F	df	p
Correct Spelling					
Group vs Cases	0.4	0.8	0.57	2/49	0.57
Trial vs T*C	0.0	0.3	0.17	2/98	0.84
G X T vs	0.5	0.3	2.02	4/98	0.10
Correct Placement					
Group vs Cases	21.9	9.2	2.36	2/49	0.10
Trial vs T*C	10.6	1.8	5.99	2/98	0.003
G X T vs T*C	10.2	1.8	5.75	4/98	0.0003
Correct Spelling and Placement					
Group vs Cases	120.7	16.5	7.29	2/49	0.0016
Trial vs T*C	322.8	2.3	137.89	2/98	0.000
G X T vs T*C	19.8	2.3	8.49	4/98	0.6

Note: T*C is Trial by Cases

2.4.5 Effects of the trials on Verbal Recall with Correct Spelling, Correct Placement, and Correct Spelling and Placement : Within Groups

Sources	MSH	MSE	F	df	p
Correct Spelling: Trial vs Trial * Cases					
gifted	0.1	0.3	0.40	2/40	0.67
average	0.5	0.3	1.71	2/32	0.20
L.D.	0.5	0.2	2.65	2/26	0.09
Correct Placement: Trial vs Trial * Cases					
gifted	1.2	1.5	0.77	2/40	0.47
average	5.3	2.2	2.40	2/32	0.11
L.D.	24.6	1.7	14.70	2/26	0.00
Correct Spelling & Placement: Trial vs Trial * Cases					
gifted	260.8	3.2	82.46	2/40	0.00
average	62.3	1.9	32.75	2/32	0.00
L.D.	39.6	1.7	24.40	2/26	0.00

2.5 Navigation Problem Solving: Group Differences

2.5.1 Means and Standard Deviations

Variables	Giftd(21) Mean(SD)	Avrge(17) Mean(SD)	L.D.(14) Mean(SD)	Total(52) Mean(SD)
Navigation	37.3(10.9)	24.5(6.3)	23.1(7.3)	29.3(10.3)

2.5.2 Oneway ANOVA

Sources	MS	F	df	p
Between Groups	1128.4	14.8	2/49	0.000
Within Groups	76.9			

2.6 Knowledge in Map Reading Skills: Group Differences

2.6.1 Means and Standard Deviations

Variables	Giftd(21) Mean(SD)	Avrge(17) Mean(SD)	L.D.(14) Mean(SD)	Total(52) Mean(SD)
Knowledge	11.6(1.8)	9.1(2.7)	8.3(3.1)	9.9(2.8)

2.6.2 Oneway ANOVA

Sources	MS	F	df	p
Between Groups	52.0	8.2	2/49	0.0008
Within Groups	6.3			

2.6.3 Duncan's Multiple Range Test

	Cont	Diffncs	SE	t	df	p
Knowledge	1	3.2	0.9	3.71	49	0.001
	2	2.5	0.8	3.07	49	0.004
	3	0.7	0.9	0.78	49	0.443

Note: Contrast 1 = Gifted vs Learning disabled
Contrast 2 = Gifted vs Average
Contrast 3 = Average vs Learning Disabled

3. Strategies Use

3.1 Sampling Strategies

3.1.1 Group Differences in the Number of Subjects who used Each Sampling Strategy: Chi Sqaures Analysis

Strateg	Random			Systmtic			Regnlly			X2	df	p
	g	a	l	g	a	l	g	a	l			
Trl 12	0	3	5	19	11	6	2	3	2	10.5	4	0.03
Trl 13	0	3	3	16	10	10	5	4	0	8.0	4	0.09
Trl 22	0	3	4	17	14	8	4	1	1	7.9	4	0.09
Trl 23	0	2	5	16	12	7	5	3	1	10.5	4	0.03
Mean	0	3	4	17	12	8	4	3	1	10.6	4	0.02

Trl 12 is the 2nd trial on the 1st map
Trl 13 is the 3rd trial on the 1st map
Trl 22 is the 2nd trial on the 2nd map
Trl 23 is the 3rd trial on the 2nd map

3.1.2 Main and Interaction Effects of the Trials and the Group on Sampling Strategies Use for the first and the second map

Sources	MSH	MSE	F	df	p
First map					
Group vs Cases	1.27	0.32	3.95	2/48	0.000
Trial vs T*C	0.15	0.24	0.64	1/48	0.4
G X T vs T*C	0.04	0.24	1.31	2/48	0.8
Second map					
Group vs Cases	1.91	0.26	7.26	2/48	0.000
Trial vs T*C	0.08	0.25	0.34	1/48	0.5
G X T vs T*C	0.11	0.25	0.47	2/48	0.6
Overall					
Group vs Cases	6.25	0.66	9.40	2/48	0.000
Trial vs T*C	0.48	0.57	0.83	1/48	0.3
G X T vs T*C	0.20	0.57	1.15	2/48	0.3

Note: T*C is Trial by Cases

3.1.3 Main and interaction effects of the sampling strategies and the groups on total Recall and spatial Recall

Sources	MSH	MSE	F	df	p
Total Recall					
Strtg vs RESID	1924.1	508.8	3.58	2/45	0.036
Group vs RESID	2981.4	508.8	5.85	2/45	0.005
S X G vs RESID	128.0	508.8	0.25	1/45	0.62
RESID	508.8				
Spatial Recall					
Strtg vs RESID	681.2	186.4	3.65	2/45	0.034
Group vs RESID	829.4	186.4	4.44	2/45	0.02
S X G vs RESID	11.7	186.4	0.06	1/45	0.83
RESID	186.4				

3.2 Encoding Strategies

3.2.1 Group Differences in the Number of Subjects Who Used Each Encoding Strategy: Chi Sqaures Analysis

Group	gifted		average		L.D.		X2	df	p
	0	1	0	1	0	1			
VERBAL ENCODING									
Knsthetic	13	8	16	1	11	3	5.5	2	0.06
Counting	16	5	15	2	14	0	4.2	2	0.13
Rehearsl	0	21	0	17	1	13	2.8	2	0.26
SPATIAL ENCODING									
Knsthtic	13	8	13	4	13	1	4.3	2	0.12
Recgntn	8	13	10	7	10	4	4.0	2	0.13
Labeling	12	9	11	6	12	2	3.2	2	0.20
Elabrtn	6	15	11	6	13	1	14.7	2	0.0006
RELATION ENCODING									
Individl	6	15	9	8	10	4	6.4	2	0.04
General	10	11	11	6	12	2	5.3	2	0.07

Note: 0 is the subjects who used strategy at least twice throughout the six study-recall trials.
1 is the subjects who used strategy less than twice throughout the six study-recall trials.

3.2.2 Group Differences in Frequencies of Stategies Use

3.2.2.1 Means and Standard Deviations

Variables	Giftd(21) Mean(SD)	Avrge(17) Mean(SD)	L.D.(14) Mean(SD)	Total(52) Mean(SD)
VERBAL ENCODING				
Kinesthetic	1.57(2.1)	0.35(0.6)	0.78(1.2)	0.96(1.6)
Counting	0.76(1.3)	0.35(0.7)	0.00(0.0)	0.42(1.0)
Rehearsal	2.90(6.5)	0.88(2.2)	0.57(0.6)	1.62(4.4)
SPATIAL ENCODING				
Kinesthetic	2.95(4.4)	0.65(1.0)	0.36(0.6)	1.50(3.1)
Recognitn	4.95(5.4)	4.53(7.3)	1.64(2.8)	3.92(5.7)
LabelingB	3.10(4.3)	2.06(4.5)	1.50(3.9)	2.33(4.3)
Elaboratn	6.67(6.3)	1.18(2.2)	1.14(3.4)	3.38(5.3)
RELATION ENCODING				
Individual	8.23(9.0)	10.00(19.5)	8.50(18.4)	8.88(15.4)
General	7.48(11.0)	1.82(3.3)	0.64(1.1)	3.79(7.8)

3.2.2.2 One Way ANOVA

Variab	MSH	MSE	F	df	p
Verbal Encoding					
Kinesthetic	7.3	2.3	3.14	2/49	0.052
Counting	2.5	0.9	2.80	2/49	0.07
rehearsal	3342.5	8469.9	0.39	2/49	0.68
Spatial Encoding					
Kinesthetic	37.5	8.4	4.46	2/49	0.000
Recognition	50.7	1.6	0.10	2/49	0.211
Labeling	11.6	18.3	0.63	2/49	0.54
Elaboration	189.7	21.2	8.97	2/49	0.0005
Relation Encoding					
Individual	16.0	246.7	0.06	2/49	0.94
General	244.9	53.0	4.62	2/49	0.014

3.2.2.3 Duncan's Multiple Range Test

Varibl	Cont	Diffncs	SE	t	df	p
Verbal Encoding						
Kinesthetic	1	0.8	0.50	1.50	49	0.14
	2	1.2	0.50	2.46	49	0.02
	3	-0.4	0.55	-0.79	49	0.43
Counting	1	0.8	0.33	2.34	49	0.02
	2	0.4	0.31	1.33	49	0.19
	3	0.4	0.34	1.04	49	0.31
Rehearsal	1	2.1	31.80	-0.77	49	0.95
	2	-23.3	33.00	0.76	49	0.44
	3	25.4	33.01	0.76	49	0.45
Spatial Encoding						
Kinesthetic	1	2.6	1.00	2.59	49	0.01
	2	2.3	0.95	2.44	49	0.02
	3	0.3	1.05	0.28	49	0.78
Recognition	1	3.3	1.94	1.71	49	0.09
	2	0.4	1.83	0.23	49	0.82
	3	2.9	2.02	1.42	49	0.16
Labeling	1	1.6	1.48	1.08	49	0.29
	2	1.0	1.40	0.74	49	0.46
	3	0.6	1.55	0.36	49	0.72
Elaboration	1	5.5	1.59	3.49	49	0.001
	2	5.5	1.50	3.66	49	0.001
	3	0.0	1.67	0.02	49	0.98
Relation Encoding						
Individual	1	-0.3	5.42	-0.04	49	0.96
	2	-1.8	5.12	-0.34	49	0.73
	3	1.5	5.22	0.27	49	0.79
General	1	6.8	2.51	2.72	49	0.009
	2	5.7	2.37	2.38	49	0.02
	3	1.2	2.63	0.45	49	0.66

Note: Contrast 1 = Gifted vs Learning disabled
Contrast 2 = Gifted vs Average
Contrast 3 = Average vs Learning Disabled

3.2.2.4 Main and Interaction Effects of Trials and Groups on Encoding Strategies Use for the First map

Sources	MSH	MSE	F	df	p
Verbal Encoding					
Rehearsal					
Group vs Cases	583.9	781.8	0.74	2/49	0.48
Trial vs T*C	465.3	82.0	5.67	2/98	0.00
G X T vs T*C	30.7	82.0	0.37	4/98	0.83
Spatial Encoding					
Kinesthetic					
Group vs Cases	6.7	1.9	3.50	2/49	0.04
Trial vs T*C	0.7	0.7	0.97	2/98	0.60
G X T vs T*C	0.5	0.7	0.69	4/98	0.60
Relation Encoding					
General					
Group vs Cases	25.3	7.0	3.58	2/49	0.04
Trial vs T*C	0.9	0.9	1.00	2/98	0.37
G X T vs T*C	0.2	0.9	0.30	4/98	0.88

3.2.2.5 Main and Interaction Effects of the Trials and the Group on Encoding Strategies Use for the Second map

Sources	MSH	MSE	F	df	p
Verbal Encoding					
Kinesthetic					
Group vs Cases	1.2	0.4	2.75	2/49	0.07
Trial vs T*C	0.6	0.4	1.71	2/98	0.18
G X T vs T*C	0.2	0.4	0.50	4/98	0.73
Spatial Encoding					
Kinesthetic					
Group vs Cases	1.0	0.3	3.74	2/49	0.03
Trial vs T*C	0.3	0.2	1.81	2/98	0.17
G X T vs T*C	0.1	0.2	0.56	4/98	0.69
Elaboration					
Group vs Cases	15.5	3.3	4.74	2/49	0.013
Trial vs T*C	0.8	2.0	0.42	2/98	0.66
G X T vs T*C	2.2	2.0	1.10	4/98	0.36
Relation Encoding					
General Relational					
Group vs Cases	16.3	3.6	4.46	2/49	0.02
Trial vs T*C	1.1	1.3	0.84	2/98	0.43
G X T vs T*C	0.7	1.3	0.51	4/98	0.72

Note: T*C is Trial by Cases

3.3 Retrieval Strategies

3.3.1 Group Differences in the Number of Subjects who used Each Retrieval Strategy: Chi Sqaures Analysis

Strtgy	Individual			General			X2	df	p
	g	a	l	g	a	l			
Trl 1	16	16	12	5	1	2	2.3	2	0.31
Trl 2	15	16	12	6	1	2	3.5	2	0.09
Trl 3	9	14	13	12	3	1	11.9	2	0.003
Ovrall	14	16	13	7	1	1	6.3	2	0.04

3.3.2 Main and interaction effects of the retrieval strategies and the groups on total Recall and spatial Recall

Sources	MSH	MSE	F	df	p
Total Recall					
Strtg vs RESID	3410.0	466.6	7.30	1/46	0.009
Group vs RESID	3465.6	466.6	7.42	2/46	0.002
S X G vs RESID	1306.1	466.6	2.79	2/46	0.07
RESID	466.6				
Spatial Recall					
Strtg vs RESID	1846.1	166.6	1.10	1/46	0.002
Group vs RESID	731.5	166.6	4.40	2/46	0.02
S X G vs RESID	441.9	166.6	2.70	2/46	0.08
RESID	166.6				
Verbal Recall					
Strtg vs RESID	237.9	242.3	0.98	1/46	0.33
Group vs RESID	1091.6	242.3	4.50	2/46	0.02
S X G vs RESID	246.3	242.3	1.01	2/46	0.37
RESID	166.6				

3.4 Monitoring Strategies

3.4.1 Group Differences in the Number of Subjects who used Each Monitoring Strategy: Chi Sqaures Analysis

	gifted		average		L.D.				
Strtgy	0*	1*	0	1	0	1	X2	df	p
Pstv evlt	14	7	16	1	12	2	4.9	2	0.09
Negtvevlt	14	7	15	2	11	3	2.5	2	0.29
Task evlt	17	4	16	1	13	1	2.0	2	0.38
Cues utlzn	10	11	10	7	12	2	5.2	2	0.07

Note: 0 is the subjects who used a strategy less than twice
1 is the subjects who used a strategy at least twice

3.4.2 Means and Standard Deviations

Variables	Giftd(21) Mean(SD)	Avrge(17) Mean(SD)	L.D.(14) Mean(SD)	Total(52) Mean(SD)
MONITORING				
Positive	1.71(4.1)	0.35(1.2)	1.21(2.6)	1.13(3.0)
Negative	2.29(4.3)	1.82(1.5)	1.64(2.9)	1.63(3.2)
Task	0.62(1.2)	0.24(1.0)	0.21(0.6)	0.38(1.0)
Cue utlztn	1.57(1.5)	1.18(1.5)	0.36(0.9)	1.12(1.4)

3.4.4 Group Differences in the frequencies of monitoring strategies use: One way ANOVA

Variab	MSH	MSE	F	df	p
Pstv evaluat	8.77	9.23	0.95	2/49	0.39
Ngtv evltn	10.04	10.49	3.96	2/49	0.39
Task evltn	0.97	1.03	0.94	2/49	0.39
Cues utlztn	6.24	1.81	3.40	2/49	0.04
Evaltn Acrcy	4756.50	546.06	8.71	2/26	0.001

3.4.4 Group Differences in the frequencies of monitoring strategies use: Duncan's Multiple Range Test

Varibl	Cont	Diffncs	SE	t	df	p
Pstv evltn	1	0.5	1.60	0.43	49	0.67
	2	1.2	1.00	1.17	49	0.25
	3	-0.7	1.10	-0.64	49	0.52
Negtv evltn	1	0.8	1.12	0.68	49	0.50
	2	1.3	1.06	1.20	49	0.22
	3	-0.6	1.18	-0.48	49	0.63
Cues Utlztn	1	1.2	0.46	2.61	49	0.01
	2	0.4	0.44	0.90	49	0.37
	3	0.8	0.49	1.69	49	0.09
Evtn Accrcy	1	43.8	10.50	4.17	26	0.00
	2	14.3	10.50	1.36	26	0.19
	3	29.5	11.70	2.53	26	0.02

Note: Contrast 1 = Gifted vs Learning disabled
Contrast 2 = Gifted vs Average
Contrast 3 = Average vs Learning Disabled

3.4.5 Main and Interaction Effects of the Trials and the Group on Monitoring Strategies Use for the First map

Sources	MSH	MSE	F	df	p
Positive Evaluation					
Group vs Cases	1.12	1.35	0.83	2/49	0.44
Trial vs T*C	0.99	0.40	2.46	2/98	0.09
G X T vs T*C	0.38	0.40	0.95	4/98	0.44
Negative Evaluation					
Group vs Cases	0.82	1.59	0.51	2/49	0.60
Trial vs T*C	3.41	0.50	6.71	2/98	0.001
G X T vs T*C	0.35	0.50	0.69	4/98	0.60
Task Evaluation					
Group vs Cases	0.01	0.01	0.10	2/49	0.90
Trial vs T*C	0.00	0.02	0.24	2/98	0.78
G X T vs T*C	0.17	0.02	0.63	4/98	0.64

3.4.6 Main and Interaction Effects of the Trials and the Group on Monitoring Strategies Use for the Second map

Sources	MSH	MSE	F	df	p
Positive Evaluation					
Group vs Cases	0.58	0.55	1.04	2/49	0.36
Trial vs T*C	0.31	0.14	2.13	2/98	0.12
G X T vs T*C	0.07	0.14	0.50	4/98	0.73
Negative Evaluation					
Group vs Cases	0.92	0.59	1.54	2/49	0.22
Trial vs T*C	0.96	0.36	2.68	2/98	0.07
G X T vs T*C	0.17	0.36	0.48	4/98	0.75
Task Evaluation					
Group vs Cases	0.20	0.07	2.84	2/49	0.07
Trial vs T*C	0.33	0.04	7.49	2/98	0.0009
G X T vs T*C	0.07	0.04	1.73	4/98	0.15
Cues Utilization					
Group vs Cases	2.07	0.60	3.44	2/49	0.04
Trial vs T*C	0.00	0.02	0.25	2/98	0.78
G X T vs T*C	0.04	0.02	1.66	4/98	0.16

4. Intercorrelations among variables

List of Variables

V 1: Spatial Recall
V 2: Verbal Recall
V 3: Navigation Problem Solving
V 4: Knowledge in Map Reading Skill
V 5: Verbal Intelligence
V 6: Quantitative Intelligence
V 7: Nonverbal Intelligence
V 8: Math Achievement
V 9: Reading Decoding Achievement
V 10: Reading Comprehension Achievment
V 11: Sampling Strategy Use on the 2nd Trial of 1st Map
V 12: Sampling Strategy Use on the 3rd Trial of 1st Map
V 13: Sampling Strategy Use on the 2nd Trial of 2nd Map
V 14: Sampling Strategy Use on the 3rd Trial of 1st Map
V 15: Frequency of Verbal Kinesthetic Strategy Use
V 16: Frequency of Verbal Counting Strategy Use
V 17: Frequency of Verbal Rehearsal Strategy Use
V 18: Frequency of Spatial Kinesthetic Strategy Use
V 19: Frequency of Spatial Recognition Strategy Use
V 20: Frequency of Spatial Labeling Strategy Use
V 21: Frequency of Spatial Elaboration Strategy Use
V 22: Frequency of Individual Relational Encoding Strategy Use
V 23: Frequency of General Relational Encoding Strategy Use
V 24: Frequency of Positive Evaluation Strategy Use
V 25: Frequency of Negative Evaluation Strategy Use
V 26: Frequency of Task Evaluation Strategy Use
V 27: Kinds of Retrieval Strategy Use
V 28: Frequency of Cue Utilization Strategy Use

4.1 Intercorrelation Coefficients for Total Subjects

	1	2	3	4	5	6	7	8	9
1.SR	1.00								
2.VR	.33	1.00							
3.NP	.37	.37	1.00						
4.MK1	.32	.31	.25	1.00					
5.IQV	.35	.36	.46	.32	1.00				
6.IQQ	.39	.39	.49	.35	.92	1.00			
7.IQNV	.40	.26	.42	.33	.85	.86	1.00		
8.Math	.36	.37	.40	.19	.85	.84	.76	1.00	
9.RESRD	.28	.37	.48	.26	.67	.63	.52	.64	1.00
10.REDC	.32	.35	.51	.43	.71	.72	.61	.62	.87
11.SMP1	.24		.27					.27	
12.SMP2		.40			.41	.38	.34	.44	
13.SMP3				.31	.26	.25			
14.SMP4	.32	.36	.33		.44	.47	.37	.41	.34
15.VKN			.26						
16.VCNT			.25		.25	.24		.25	.25
17.VRHS				.26			.23		
18.SKIN	.38				.27	.30	.33	.24	
19.SREC			.25						
20.SLAB	.32						.25		
21.SEL	.53	.57	.41	.40	.42	.40	.42	.40	.32
22.RIN		.29							
23.RGEN		.31	.34		.30	.30	.26	.29	.31
24.EP									
25.EN									
26.ET									
27.RTRV	.44		.31			.32	.28	.27	
28.CUEUT		.37	.27	.25	.29	.37		.31	.37

	10	11	12	13	14	15	16	17	18
10.RDC	1.00								
11.SMP1		1.00							
12.SMP2			1.00						
13.SMP3	.24			1.00					
14.SMP4	.36	.32			1.00				
15.VKIN					.25	1.00			
16.VCNT	.26					.35	1.00		
17.VRHS	.27		.33	.34	.33			1.00	
18.SKIN						.41			1.00
19.SREC					.30	.36		.25	
20.SLAB					.24				
21.SEL	.31				.35	.37	.23		.40
22.RIND					.38	.35			-.05
23.RGEN	.30							.36	
24.EP									
25.EN									
26.ET									.39
27.RTRV									
28.CUEUT									.39

	19	20	21	22	23	24	25	26	27
19.SREC	1.00								
20.SLAB		1.00							
21.SEL	.31	.61	1.00						
22.RIND	.32	.35		1.00					
23.RGEN	.54		.42	.32	1.00				
24.EP						1.00			
25.EN						.85	1.00		
26.ET						.28	.30	1.00	
27.RTRV	.24					.26			1.00
28.CUET			.25		.36				

	28
28.CUET	1.00

4.2 Intercorrelation Coefficients for the Gifted

	1	2	3	4	5	6	7	8	9
1.SR	1.00								
2.VR		1.00							
3.NP			1.00						
4.MK1				1.00					
5.IQV					1.00				
6.IQQ						1.00			
7.IQNV							1.00		
8.Math	.69							1.00	
9.RESRD									1.00
10.REDC									
11.SMP1									
12.SMP2									
13.SMP3									
14.SMP4									
15.VKN									
16.VCNT									
17.VRHS									
18.SKIN									-.72
19.SREC									
20.SLAB									
21.SEL									
22.RIN									
23.RGEN									
24.EP						.51			
25.EN									
26.ET									-.63
27.RTRV									.54
28.CUEUT									

	10	11	12	13	14	15	16	17	18
10.RDC	1.00								
11.SMP1		1.00							
12.SMP2			1.00						
13.SMP3				1.00					
14.SMP4					1.00				
15.VKIN						1.00			
16.VCNT							1.00		
17.VRHS			.57	.54	.50			1.00	
18.SKIN	-.67								1.00
19.SREC						.59			
20.SLAB									
21.SEL									
22.RIND									
23.RGEN									
24.EP									
25.EN									
26.ET	-.76								
27.RTRV									
28.CUEUT									

	19	20	21	22	23	24	25	26	27
19.SREC	1.00								
20.SLAB		1.00							
21.SEL		.78	1.00						
22.RIND				1.00					
23.RGEN	.63			.65	1.00				
24.EP						1.00			
25.EN						.92	1.00		
26.ET								1.00	
27.RTRV									1.00
28.CUET									

	28
28.CUET	1.00

4.3 Intercorrelation Coefficients for the Average

	1	2	3	4	5	6	7	8	9
1.SR	1.00								
2.VR		1.00							
3.NP			1.00						
4.MK1	.57			1.00					
5.IQV					1.00				
6.IQQ						1.00			
7.IQNV							1.00		
8.Math	.69							1.00	
9.RESRD									1.00
10.REDC									
11.SMP1									
12.SMP2					.65				
13.SMP3									
14.SMP4		.57							
15.VKN									
16.VCNT									
17.VRHS				.60				-.84	
18.SKIN								-.61	
19.SREC									
20.SLAB									
21.SEL									
22.RIN									
23.RGEN									
24.EP									
25.EN									
26.ET									
27.RTRV									
28.CUEUT						.64			

	10	11	12	13	14	15	16	17	18
10.RDC	1.00								
11.SMP1		1.00							
12.SMP2			1.00						
13.SMP3				1.00					
14.SMP4					1.00				
15.VKIN						1.00			
16.VCNT							1.00		
17.VRHS								1.00	
18.SKIN									1.00
19.SREC									
20.SLAB									
21.SEL						.60			
22.RIND			.59						
23.RGEN									
24.EP									
25.EN						.71			
26.ET									
27.RTRV									
28.CUEUT									

	19	20	21	22	23	24	25	26	27
19.SREC	1.00								
20.SLAB		1.00							
21.SEL			1.00						
22.RIND				1.00					
23.RGEN	.74			.65	1.00				
24.EP		.90				1.00			
25.EN			.86				1.00		
26.ET								1.00	
27.RTRV									1.00
28.CUET									

	28
28.CUET	1.00

4.4 Intercorrelation Coefficients for the Learnig Disabled

	1	2	3	4	5	6	7	8	9
1.SR	1.00								
2.VR		1.00							
3.NP			1.00						
4.MK1				1.00					
5.IQV					1.00				
6.IQQ					.93	1.00			
7.IQNV					.89	.92	1.00		
8.Math					.89	.83		1.00	
9.RESRD									1.00
10.REDC								.84	
11.SMP1	.73		.70						
12.SMP2									
13.SMP3									
14.SMP4				-.69					
15.VKN					-.86	-.79	-.76		
16.VCNT									
17.VRHS									
18.SKIN					-.70	-.71	-.74	-.65	
19.SREC									
20.SLAB									
21.SEL									
22.RIN				-.76					
23.RGEN									
24.EP									
25.EN									
26.ET									
27.RTRV									
28.CUEUT									

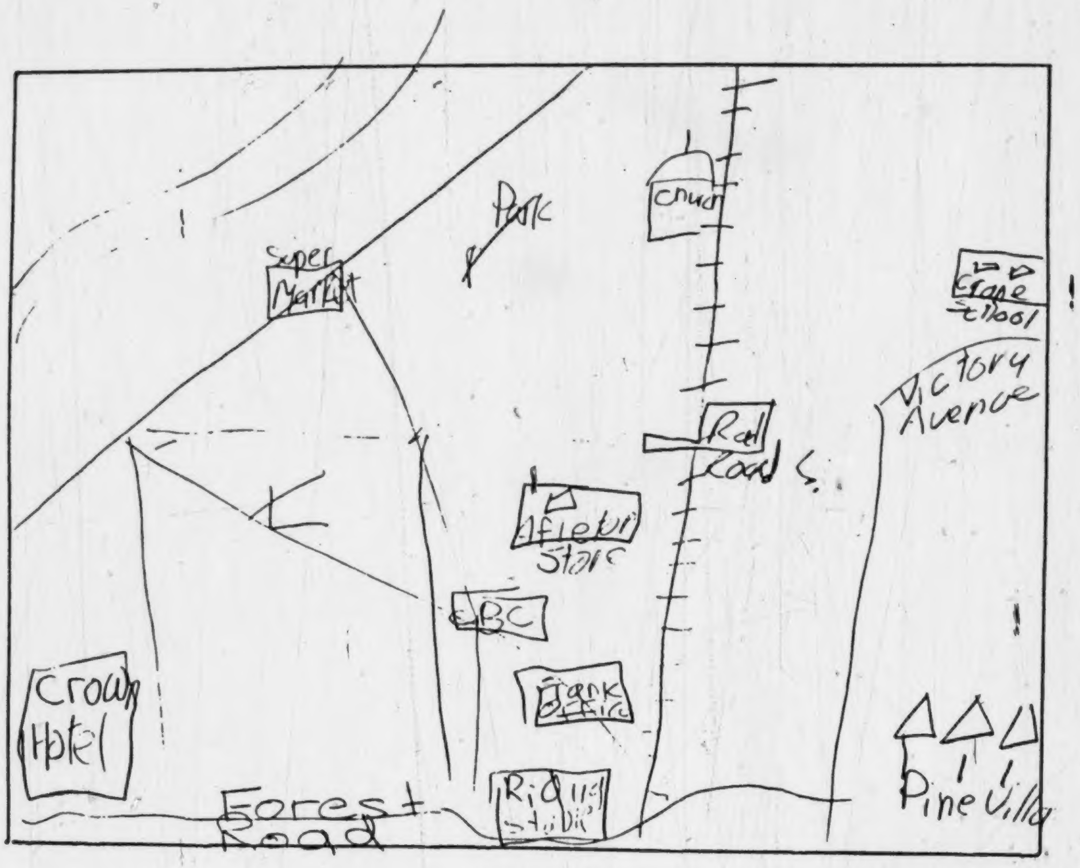
	10	11	12	13	14	15	16	17	18
10.RDC	1.00								
11.SMP1		1.00							
12.SMP2			1.00						
13.SMP3				1.00					
14.SMP4					1.00				
15.VKIN						1.00			
16.VCNT							1.00		
17.VRHS								1.00	
18.SKIN						.72			1.00
19.SREC									
20.SLAB									
21.SEL					.65				
22.RIND					.67				
23.RGEN									
24.EP									
25.EN									
26.ET									
27.RTRV									
28.CUEUT									

	19	20	21	22	23	24	25	26	27
19.SREC	1.00								
20.SLAB		1.00							
21.SEL	.66	.87	1.00						
22.RIND	.61	.79	.93	1.00					
23.RGEN					1.00				
24.EP						1.00			
25.EN						.83	1.00		
26.ET								1.00	
27.RTRV									1.00
28.CUET									

	28
28.CUET	1.00

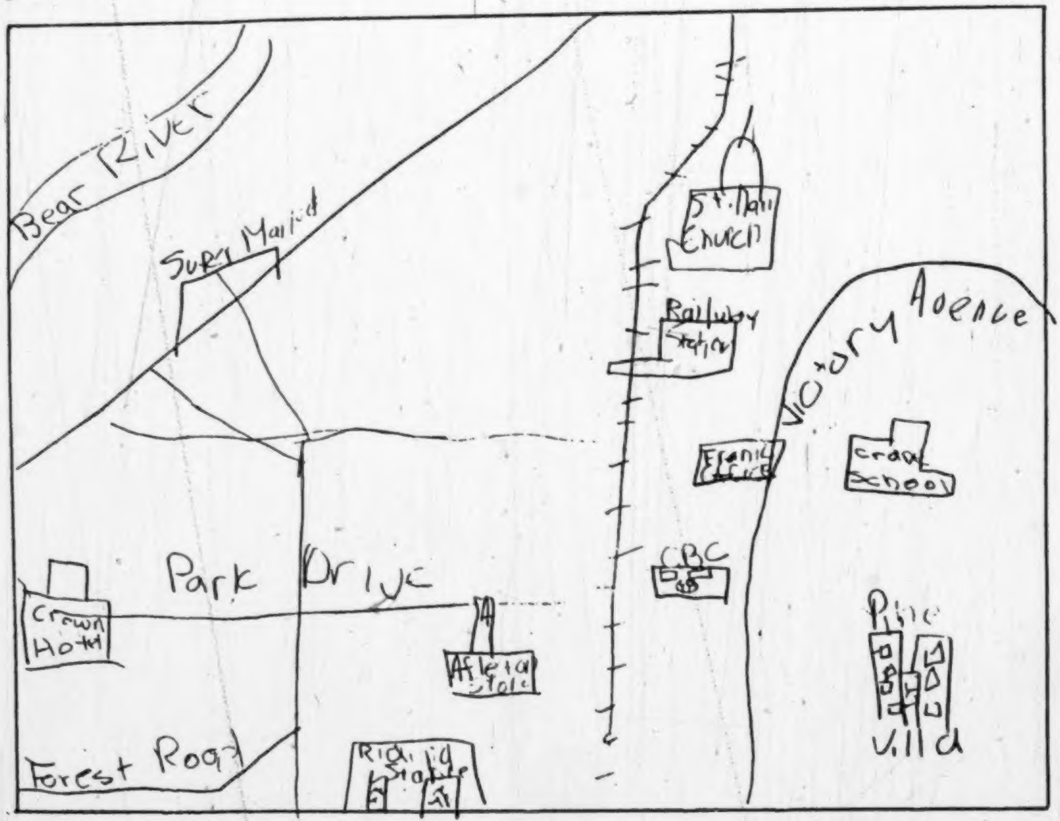
Appendix I: Examples of Cases

1. the Gifted
    - Map Reproduction and Score
    - Verbal Protocol and Strategy Analysis
    - Retrieval Strategy


Super Market
Park
chuch
Crane school
Victory Avenue
Rail Road S.
Afleton Store
CBC
Frank office
Crown Hotel
Forest Road
Riding stable
Pine Villa

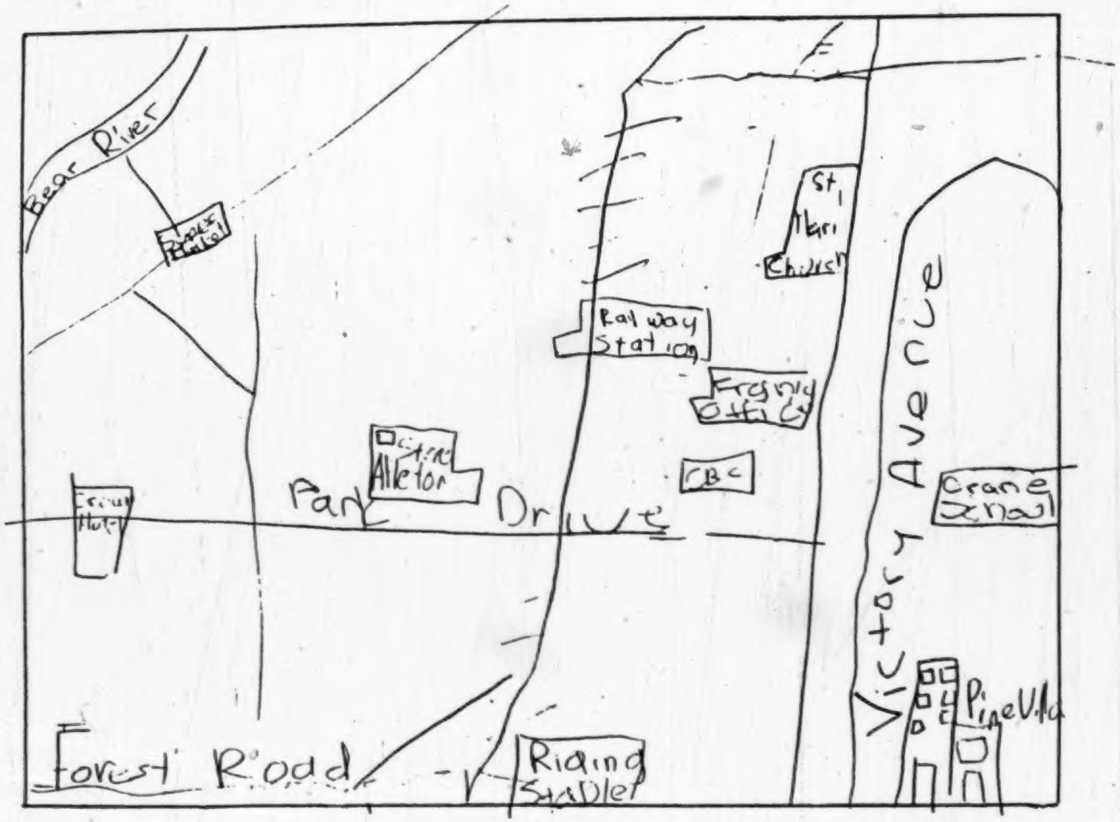
Town map 1

1. ~~afleton store~~
2. Bear river
3. ~~CBC~~
4. Crane school
5. ~~Crown hotel~~
6. forest road
7. Frank office
8. park drive
9. ~~pine villa~~
10. ~~railway station~~
11. ~~riding stable~~
12. ~~St. mari~~ church
13. ~~super market~~
14. ~~victory avenue~~


Bear River
Super Market
St. Mari Church
Railway Station
Victory Avenue
Frank Office
Crane School
CBC
Park Drive
Crown Hotel
Afletan Store
Pine Villa
Forest Road
Riding Stable

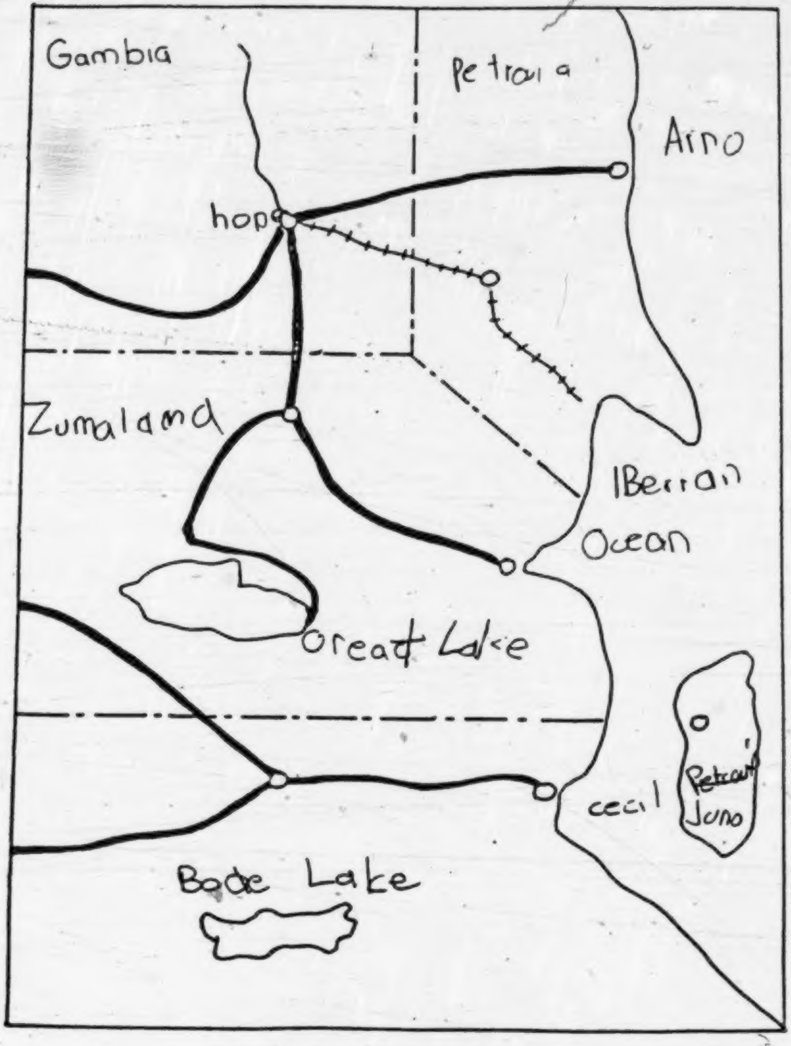
Town map 2

1 ~~afleton store~~
2 ~~Bear river~~
3. ~~CBC~~
4 ~~Crane school~~
5 ~~Crown hotel~~
6. ~~forest road~~
7. ~~Frank office~~
8. ~~park drive~~
9 ~~pine villa~~
10 ~~railway station~~
11 ~~riding stable~~
12. ~~St meri church~~
13 ~~super market~~
14 ~~victory avenue~~

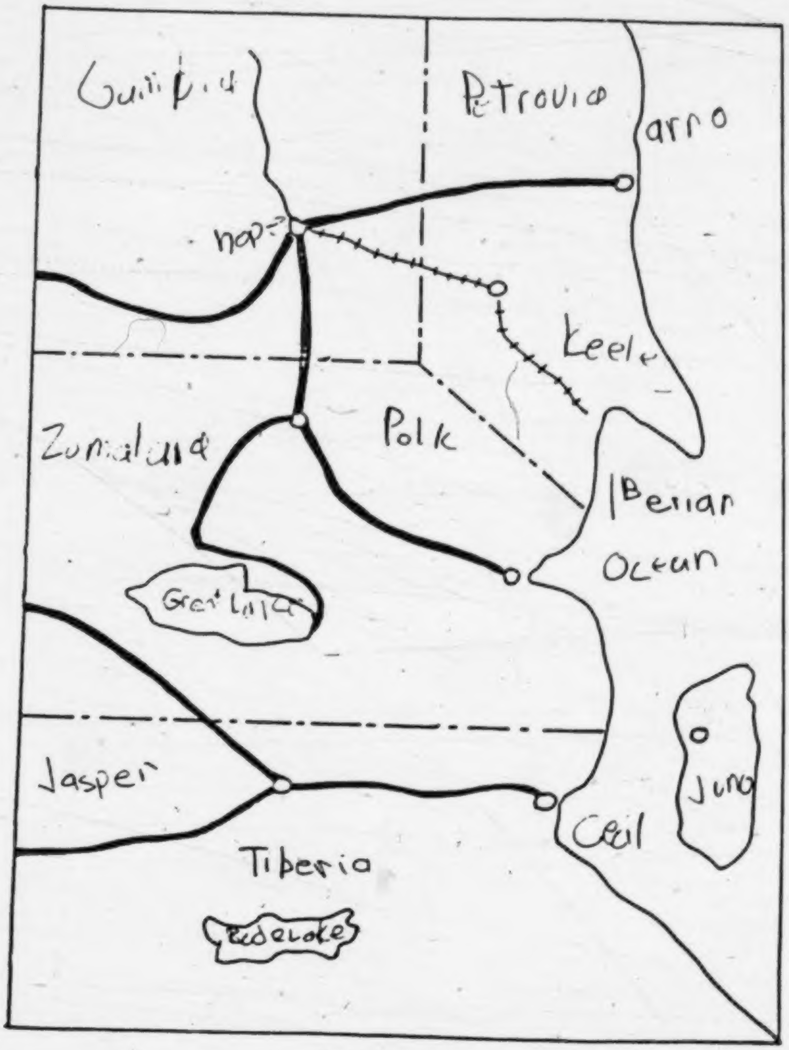

Bear River
Super Market
Crown Hotel
Store Alleton
Park Drive
Railway Station
St. Mari Church
Frank Office
CBC
Crane School
Victory Avenue
Pine Villa
Forest Road
Riding Stable

Town map. 3

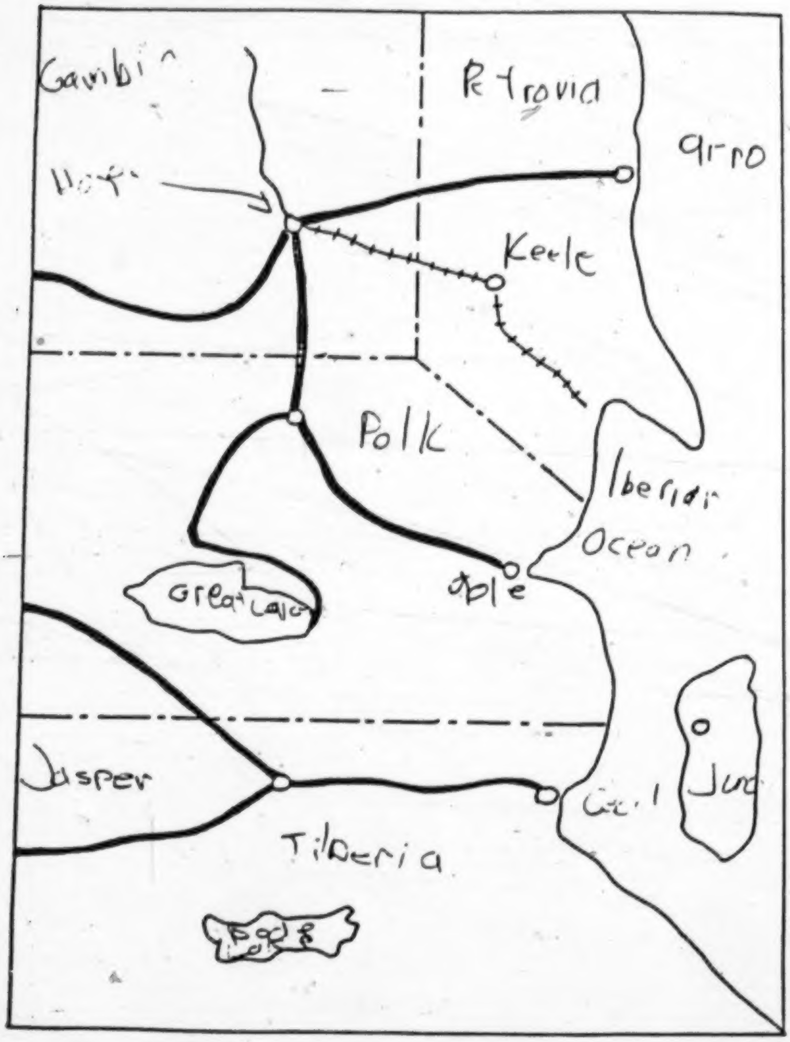
~~1. afleton store~~
~~2. Bear river~~
~~3. CBC~~
~~4. Crane school~~
~~5. Crown hotel~~
~~6. forest road~~
7. Frank office
~~8. park drive~~
~~9. pine villa~~
~~10. railway station~~
~~11. riding stable~~
~~12. St. mari church~~
~~13. super market~~
~~14. victory avenue~~


Gambia
Petraia
Airo
hope
Zumaland
IBerran
Ocean
Great Lake
cecil
Petraia
Juno
Bode Lake

Countries map 1


Guilipua
Petrovia
arro
nap
Keele
Zumalura
Polk
IBerian
Ocean
Great Lake
Jasper
Juno
Ceil
Tiberia
Redelake

Countries map 2


Gambia
Hofi
Petrovia
girro
Keele
Polk
Iberian
Ocean
Great Lake
able
Jasper
Tiberia
Cecil
Jud
Pool

Countries map 3

Scoring Sheet on Map Learning

Unlabeled Spatial Information

	1		2		3		T	
	A	R	A	R	A	R	A	R
1	/		/		/			
2	/		/		/			
3	/		/		/			
4		0		0		2		
5		2		2		2		
6		2		2		3		
7		1		1		2		
8		1		1		/		
9						0		
10						4		
11					/			
12		3		3		4		
13		4		4		4		
14						4		
15						0		
16						0		
17			/		/			
18		3		2		4		
19		3	/			4		
20			/			2		
21	/		/		/			
22		/	/		/			
23		/	/		/			
24		/	/		/			
25					/			
26					/			
27					/			
28	/			2		/		
29	/			/	/			
30	/			/	/			
31								
32								
33								
34								
35								
T	7	22	10	17	14	37		

Verbal Information

	1		2		3		T	
	v	s	v	s	v	s	v	s
1	/	/	/	/	/	/		
2	/	/	/	/	/	/		
3	/	/	/	/	/	/		
4					/	/		
5	/	/	/	/	/	/		
6	/	/	/	/	/	/		
7	/	/	/	/	/	/		
8			/	/	/	/		
9	/	/	/	/	/	/		
10			/	/	/	/		
11	/	/	/	/	/	/		
12			/	/	/	/		
13	/	/	/	/	/	/		
14			/	/	/	/		
15	/	/	/	/	/	/		
T	10	10	14	14	15	15		

Name_______________

____

School_______________

Date_______________

Condition_______________

Labeled Spatial Information

	1		2		3		T	
	A	R	A	R	A	R	A	R
1		2	/		/			
2		0		2	/			
3	/.		/		/			
4		4		6		5		
5		/		3	/			
6		2	/		/			
7		0	/		/			
8		0	/		/			
9	/		/		/			
10		2	/		/			
11		2	/			3		
12		3		2		3		
13	/			2		3		
14	/				/			
15								
T	3	16	8	15	10	14		

VERBAL PROTOCOL: Example 1

1. Town map: Spatial Recall
   a. 1st trial
      Bear river leads to the supermarket. That leads to the church along the railway. Then, church, the office, CBC as afleton store, crown hotel, forest road, riding stable, pine villa, crane school, victory avenue, St. marie church.
      So, CBC and usually right there.
      Center of it riding stable, afleton store.
      Right is a little more remote.
      I got to rememeber this.
      I think I got it. Sort of. I got where.
      I see the pattern on he road.
      I don't quite. There, this, the rail raod across the thing, afleton store.

   b. 2nd trial
      Bear river, CBC, park drive, riding stable.
      So I didn't get all after all.
      Oh, I see now.
      Crane school, pine villa. Oh, I see. There, have it. I think.
      The rail road across the park drive. Frank office, CBC, railway station, St. marie church, crane school, pine villa.
      St. marie church, where does it got?
      Oh, I see, I hae it. I'm ready. Let me practice.
      Now I see it.
      The roads (drawing on the desk with finger).

   c. 3rd trial
      It's going too far. What is this supposed to be? Draw it again?
      Oh, I forgot that road. Oh, I didn't do pretty good. The road went up that was. Actually it was not accurate. How could I be that bad! I mixed up. Let's see which one is better later. I was just weaving the location. I forgot that road (referring to '4'). I see. I didn't forget that road. That was good. Pine villa. I've got it. right. riding stable. afleton store, ok. Frank office, CBC, Frank office may be there. It wasn't too bad. St. marie church. I got it. Did you draw this map?

1. Countries Map: Verbal recall
    a. 1st trial

    What is this? Oh, no. I think. It can be bad. Gambia, Zumaland, great lake, dole, jasper, Tiberia, Bode lake, cecil, juno, Iberian Ocean, arno, Petrovia, keele, pole, dole, lake. I think I see what I am going to be doing. Zumaland, polk, dole, great lake, jasper, Tiberia, bode lake, cecil, juno, Iberian Ocean, arno, keele, I, sort of, like a, got the area. I can memorize. Curve, There at the area.

    b. 2nd trial

    Oh, that's polk. Oh, Petrovia was there. I was lucky. I forgot. Tiberia, Jasper. I missed some. polk, keele. I missed dole. Tibveria. Four things, Four things. I missed jasper completely. I am trying to review everything.
    So, great lake, dole, Zumaland in one area.
    polke, keele, and Petrovia in one longitude.
    arno, Iberian Ocean and cecil and juno ae each one in one area.
    Tiberia and bode lake in one aea.
    jasper as in that area. And that area is empty.
    I think I have to review it.
    Gambia, hope, in one area. Petrovia, keele, polke in one area.
    Zumaland, dole, great lake in one area.
    Iberian Ocean, arno, cecil, juno in one area.
    Jasper, Tiberia, bode lake in one area.

    c. 3rd trial

    Oh, that's dole. Other than that every thing is right.
    That's best. dole, so. Remember dole. I got the other sides. So I don't need too much. I think I got them all.

RETRIEVAL STRATEGY: Example 1

Town map

a. 1st trial
5, 6, 7, 8, 28, 29, 30, 21, 22, 23, 24, 12, 18, 19, 20, 1, 2, 3, (13), (10), (9), (4), (14), (12), (3), (14), (15), (1), (5), 17, 14, 15, (7), (11), (8).

b. 2nd trial
5, 6, 7, 8, 21, 22, 23, 24, 1, 2, 3, (2), (9), 12, 18, 19, 20, 13, 14, 28, 29, 30, (3), (1), (4), (5), 17, (6), (7), (8), (10), (11), (12), (13), (14)

c. 3rd trial 1, 2, 3, (2), 4, 5, 6, 7, 8, (13), 11, 10, 25, 26, 27, 28 , 29, 30, victory avenue, 21, 22, 23, 24, 13, 14, (5), 17, (6), 21, 22, 23, 24, 10, (9), (1), (12), 33, (8), (11), (10), (3), (4), 12, 18, 19, 20, (7)

STRATEGY ASSESSMENT

Name ____________________
School____________________

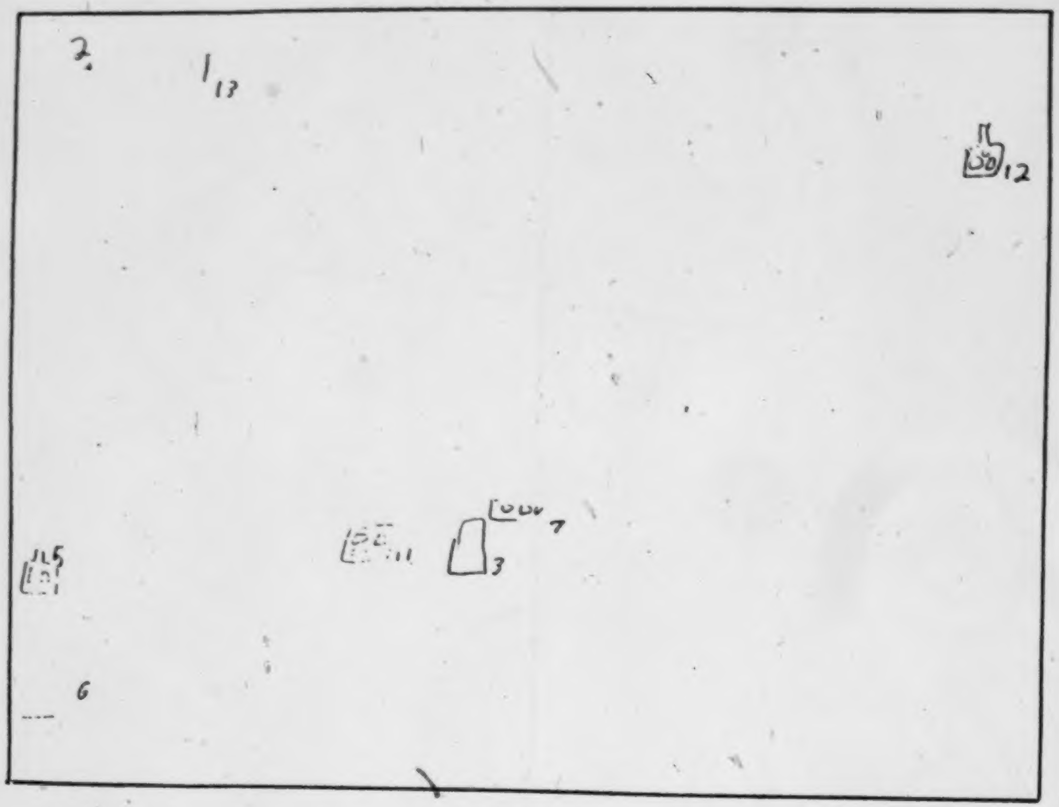
	1		2		3		1		2		3	
Sampling random												
systematic				/						/		
regionally-focused						/						/
Encoding Verbal kinesthetic												
counting												
rehearsal	𝍸 𝍸 𝍸	15	𝍸 𝍸///	13	𝍸	[illegible]	[illegible]	29	𝍸 /	6		
Spatial kinesthetic			//	2								
recognition	/	/	/	/								
labeling												
elaboration						/		/		/		
Relational individual	///	[illegible]		/				/	[illegible]	15		
general	//	2							𝍸	5		
Retrieval separate												
main frame		/		/		/						
Monitoring Evaluation positive	///	3	//	2	𝍸 /	6	///	3	/	1	////	4
negative	/	1	////	4	𝍸 //	7		1	𝍸	5	/	/
task								/				/
Cues utilization cross-out		/		/	—	/						

2. the Average

Map Reproduction and Score

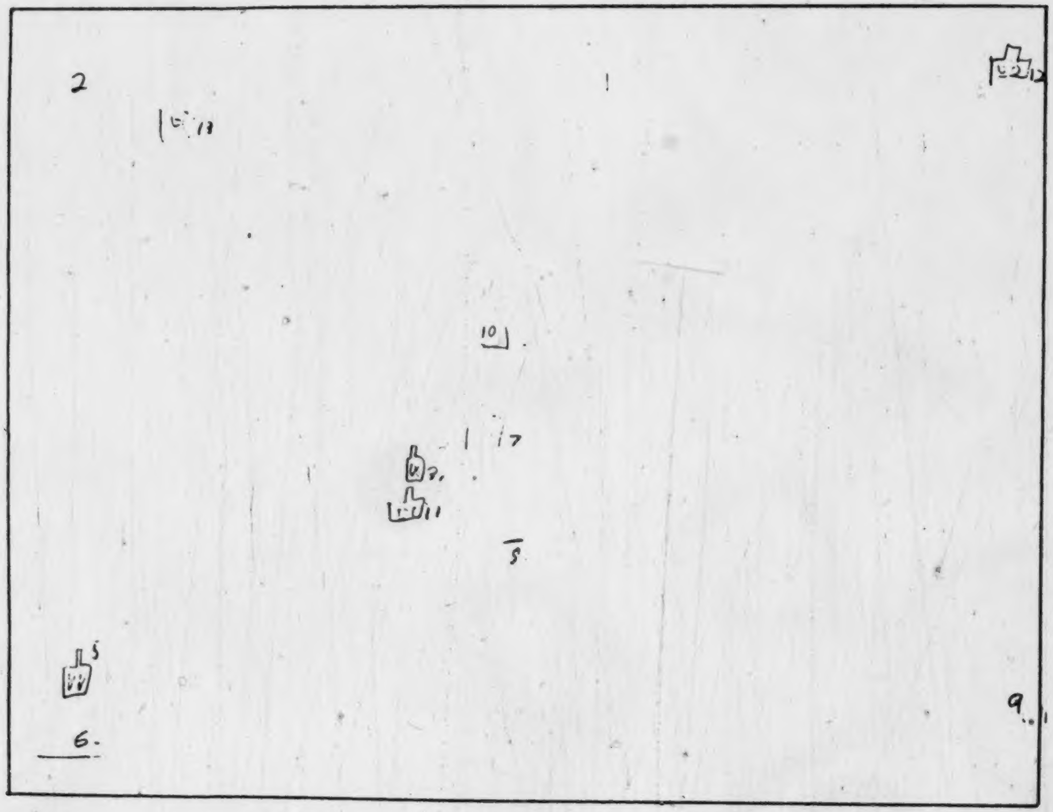
Verbal Protocol and Strategy Analysis

Retrieval Strategy



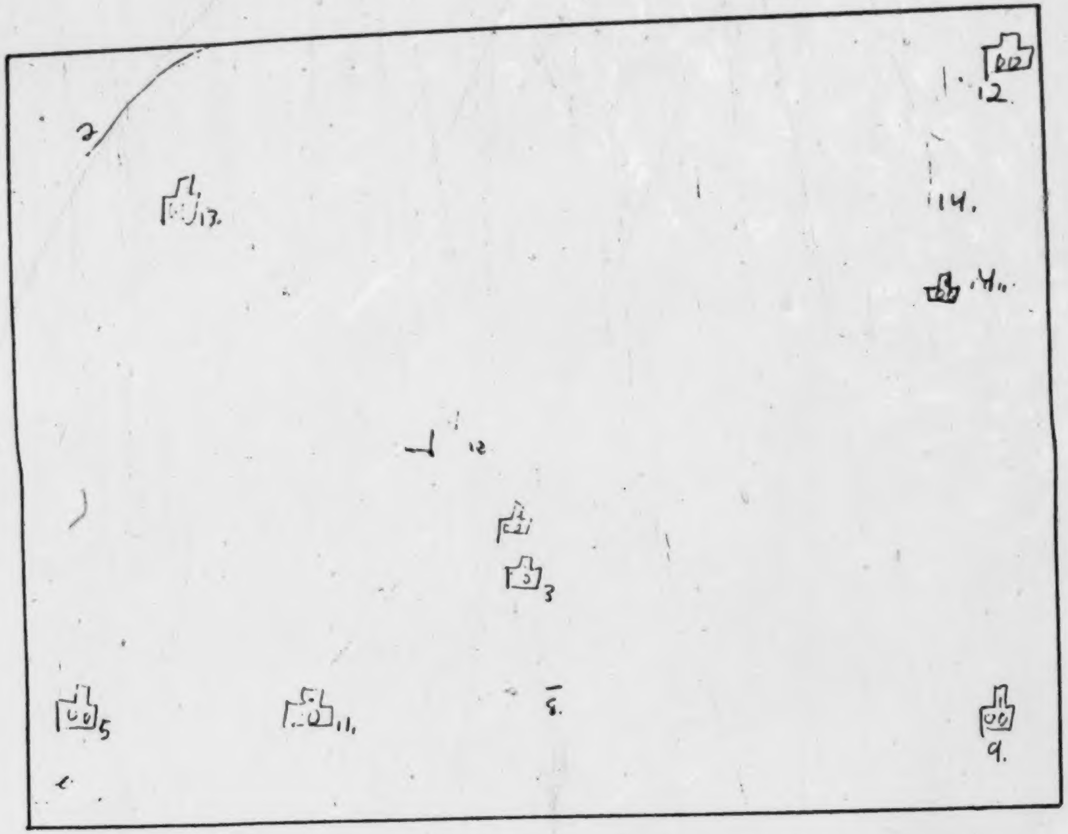
Town map. 1

1. afleton store
2. Bear river
3. CBC
4. Crane school
5. Crown hotel
6. forest road
7. Frank office
8. park drive
9. pine villa
10. railway station
11. riding stable
12. St. mari church
13. super market
14. victory avenue



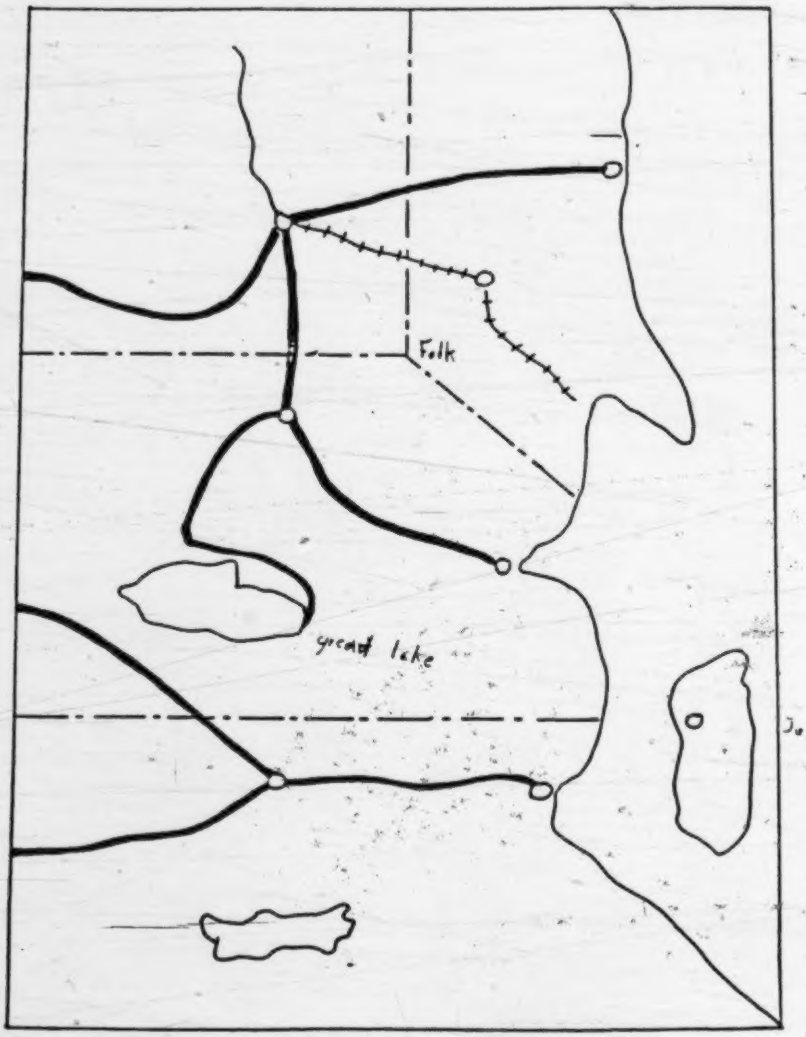
Town map 2

1. afleton store
2. Bear river
3. CBC
4. Crane school
5 Crown hotel
6 forest road
7 Frank office
8. park drive
9 pine villa
10. railway station
11. riding stable
12 St. mari church
13 super market
14. victory avenue

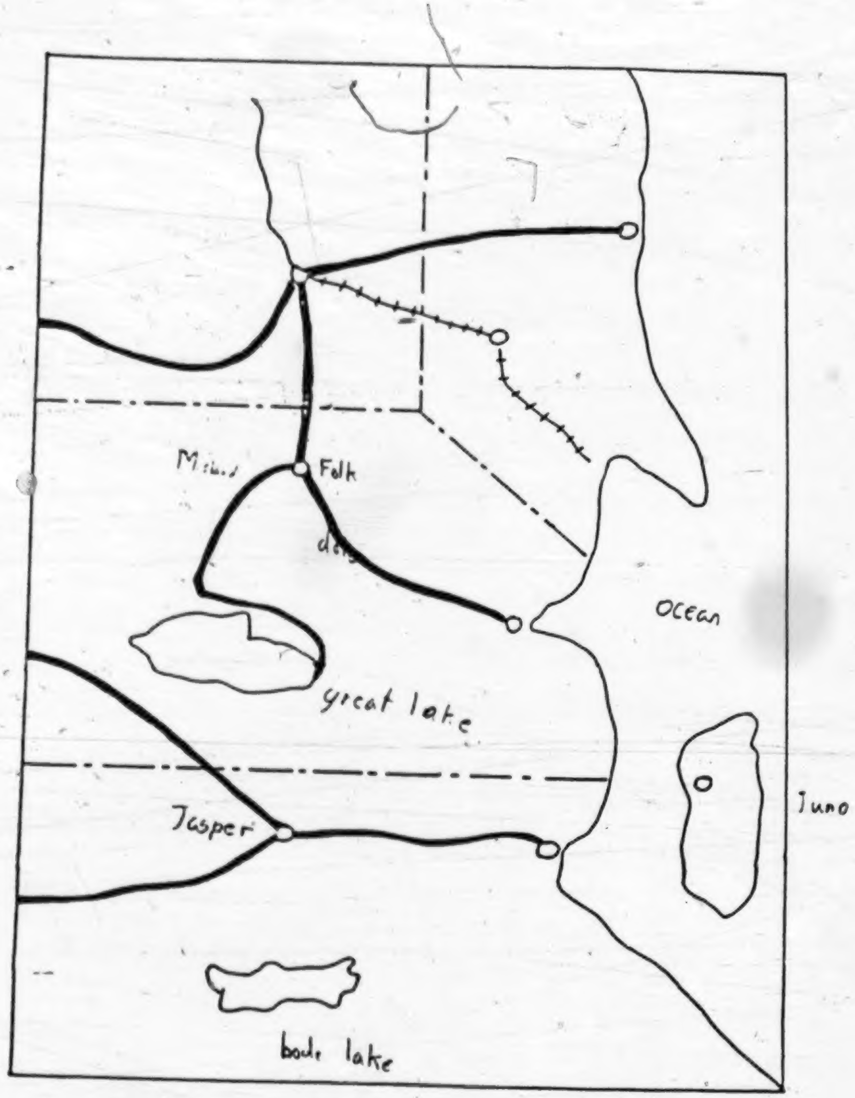


Town map . 3

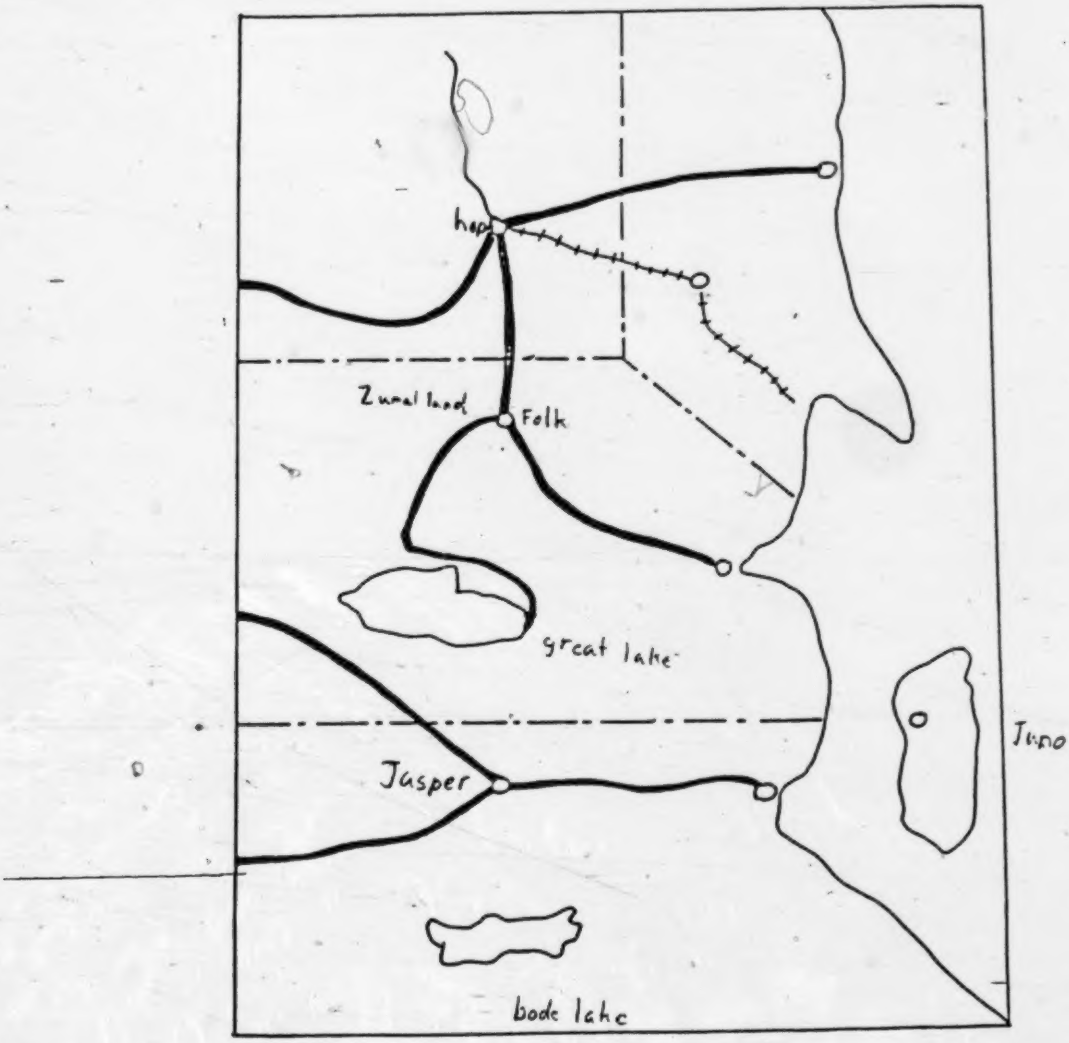
1. afleton store
2. Bear river
3 CBC
4. Crane school
5 Crown hotel
6. forest road
7. Frank office
8. park drive
9. pine villa
10. railway station
11. riding stable
12. St. mari church
13. super market
14. victory avenue


Folk
great lake
Jo

Countries map 1


Folk
Ocean
great lake
Jasper
Juno
bode lake

Countries map 2


hop
Zunal land
Folk
great lake
Juno
Jasper
bode lake

Countries map 3

Scoring Sheet on Map Learning

Unlabeled Spatial Information

	1		2		3		T	
	A	R	A	R	A	R	A	R
1	/		/		/			
2	/		/		/			
3	/		/		/			
4				2		/		
5								
6								
7				/				
8				/				
9								
10								
11								
12								
13								
14								
15								
16								
17	/		/		/			
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
31								
32								
33								
34								
35								
T	4	0	4	4	4	1		

Verbal Information

	1		2		3		T	
	v	s	v	s	v	s	v	s
1								
2			/	/	/	/		
3								
4			/					
5				/				
6								
7	/	/	/	/	/	/		
8								
9					/	/		
10			/	/	/	/		
11		/	/	/	/	/		
12				/		/		
13								
14								
15				/	/	/		
T	1	2	5	7	6	7		

Name______________

____

School____________

Date____________

Condition__________

Labeled Spatial Information

	1		2		3		T	
	A	R	A	R	A	R	A	R
1		0		0		0		
2	/		/		/			
3		2		3		3		
4		0		0		3		
5		3		3		3		
6	/		/		/			
7		2		3		0		
8		0	/			2		
9		0	/		/			
10		0	/			2		
11		2		2	/			
12		2		2		2		
13		2		3		3		
14		0		0	/			
15								
T	2	13	1	16	1	18		

VERBAL PROTOCOL: Example 2

1. Town Map: Spatial Recall
   a. 1st trial
      CBC. Bear river, Bear river is up there. A line comes down. Super market is right by the Bear river. St. marie chruch is on he top. There's a lake. Pine. Forest road at the bottom. Crown hotel is right there. Super market by the Bear river. Riding stable is across from pine. Forest road is at the bottom. Crown hotel is above it. CBC is in the center. Right there.
   b. 2nd trial
      Super market is up here. Crown hotel. Riding stable is there, pine villa. That was right there. CBC was, CBC below. Park drive is right across from the crown hotel. Forest road, riding stable. That's where it was. Railway station was above the office. CBC across is store. Bear river is at the top. Super market is right there. St. marie church is up there. Victory avenue is right there. Park drive is right there. Railway station, riding stable, pine villa, school. St. marie church is up there. Railway station, super market.
   c. 3rd trial
      Ok. Super market, St. marie church, victory avenue is below St. marie church. Crane school is below. Victory aveneu, pine villa, ok. park drive, ok, frank office, crown hotel. forest road, railway station, Frank office is about there. Frank office. CBC is below it. Park drive is below it. riding stable is by park drive. Crane school is below victory avenue. St. marie church is at the top of the map. Crown hotel, Forest road. Riding stable is there. Park drive is there. Afleton store is there. Railway station is there. Victory avenue.

2. Countries Map: Verbal Recall

a. 1st trial

Bode lake. Jasper is right there. Tiberia, keele, ocean, dole, Great lake, dole. Great lake is there. Polk is there. Hope is there. arno and keele, great lake by dole. ocean, bode lake, jasper, Zumaland, Zumaland, polk, Petrovia is at the top of the map. Arno is right there. Polk is right there. Great lake is right there.

b. 2nd trial

arno, keele, hope, polk, great lake, bode lake, jasper is by the wish bon. jasper, jasper, Tiberia, great lake, bode lake, cecil, jasper, great lake, bode lake, cecil, jasper, great lake, dole, polk, dole, dole, dole. great lake is by dole. dole, polk, polk, great lake by dole. Jasper is at the wish bon. Bode lake is at the very bottom. Zumaland is by polk.

c. 3rd trial

bode lake, juno, alright. Zumaland, hope. Arno is there. That's keele, hope. That was jasper. great lake, keele, bode lake, juno, cecil, hope is right there. keele, arno. Great lake is right there. Jasper wish bon again, polk, Zumaland, hope is up there. keele is up threre. keele, arno, Zumaland.

RETRIEVAL STRATEGY: Example 2

Town map

- a. 1st trial
  1, 2, 3, 17, (6), (13), (11), (7), (3), (2), (5), (12).
- b. 2nd trial
  1, 2, 3, 4, 7, 8, (13), (2), 17, (6), (5), (7), (3), 13, 14, (8), (9), (10), (11), (12).
- c. 3rd trial
  1, 2, 3, 4, (13), (12), (9), 17, (6), (5), (2), (7), (3), (11), (10), 13, 14, (8), (25), (14), (4)

STRATEGY ASSESSMENT

Name ______ – __________
School________________

	1		2		3		1		2		3	
Sampling **random**				/		/				/		/
systematic												
regionally-focused												
Encoding **Verbal** **kinesthetic**												
counting												
rehearsal		2		16		11		13		26		[illegible]
Spatial **kinesthetic**												
recognition	//	2	𝍸	5	///	4	////	4	𝍸 //	7	𝍸 /	6
labeling									/	/	/	/
elaboration												
Relational **individual**	///	4	𝍸	5	𝍸 /	6	/	/	𝍸	5		0
general	𝍸 /	6	//	2	/	/	/	/	/	/	/	/
Retrieval **separate**		/		/		/						
main frame												
Monitoring **Evaluation** **positive**					//	2						
negative			/	/								
task												
Cues utilization **cross-out**		/		/		/						